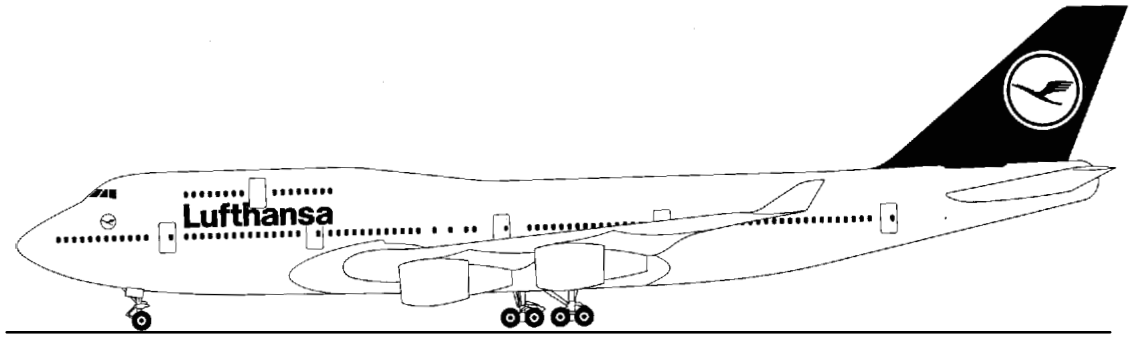
Lufthansa Technical Training

Training Manual B 747-400



ATA 34-46 EGPWS

ATA Spec 104 Level III

Book No:

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Issue: May 2001

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ATA 34-46 ENHANCED GROUND PROXIMITY WARNING SYSTEM

GROUND PROXIMITY WARNING SYSTEM INTRODUCTION

The purpose of the ground proximity warning system (GPWS) is to alert the flight crew about a condition that is not safe because of near terrain. It also provides a warning when windshear conditions are present.

Aural messages, lights and CRT displays annunciate GPWS warnings and alerts in the flight deck.

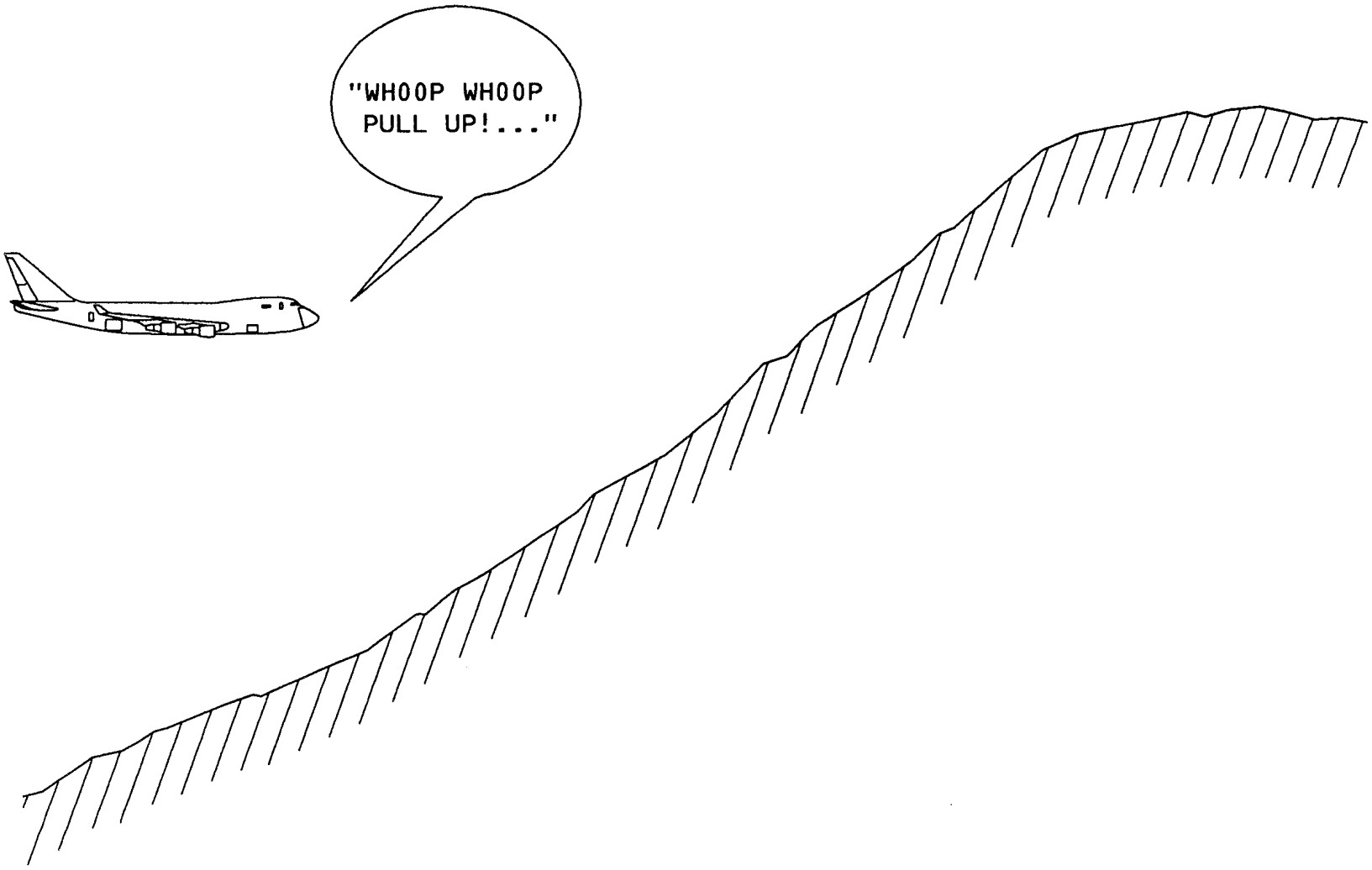

Figure 1 GPWS INTRODUCTION

GROUND PROXIMITY WARNING SYSTEM

System Overview

The main component of the GPWS is the ground proximity warning computer (GPWC). It uses inputs from the various systems to determine the presence of an unsafe condition due to ground proximity and then issues the proper annunciations.

The GPWS displays terrain forward of the airplane and also alerts the flight crew to early descent when landing.

Visual annunciations show on the:

- Primary flight display (PFD)
- Navigation displays (NDs)
- GPWS warning module
- Master warning lights

Aural annunciations sound from the aural warning speakers.

The GPWC sends terrain data to show on the NDs.

Status

Systems status shows on the auxiliary EICAS display.

The left and the right CMCS receive status information for recording in memory and display on the CDUs.

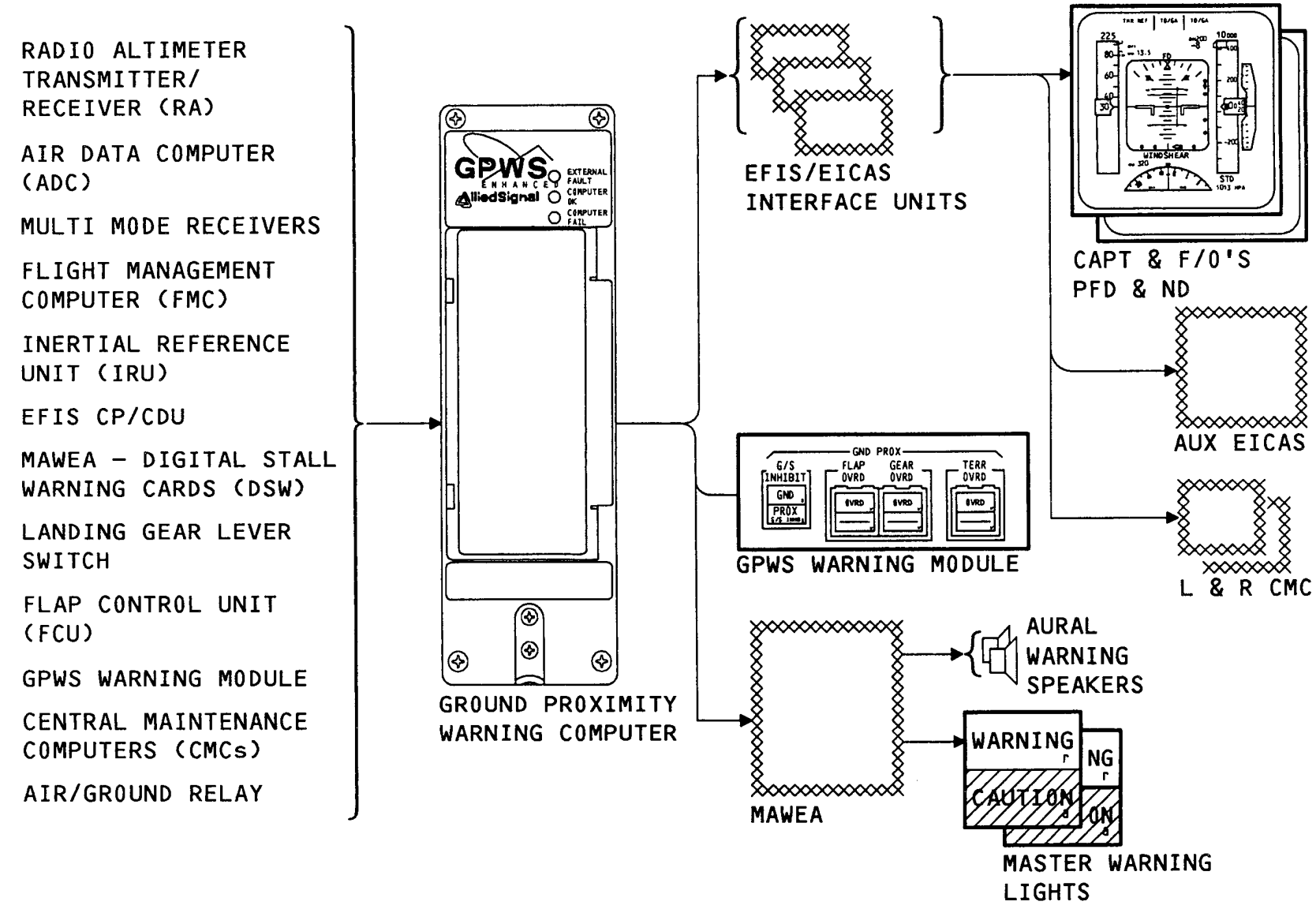

Figure 2 GROUND PROXIMITY WARNING SYSTEM

GROUND PROXIMITY MODES

The GPWS has seven modes and two terrain alerting and display (TAAD) functions. The graphic shows their descriptions and annunciations.

The GPWS utilizes two kinds of indications: warnings and alerts.

The warnings include:

- A red indication on the PFD and ND
- An aural annunciation
- The illumination of the master warnings lights

The alerts do not include PFD indications and the illuminations of the master warning lights. Instead, they include an aural annunciation and the illumination of the amber GND PROX-G/S INHE light/switch on the GPWS warning module and an amber indication on the ND in all cases except the radio altitude callouts.

Modes 1 and 2 are both alert and warning modes. The initial annunciation is an alert. If the condition persists, the respective warning replaces the alert.

Modes 3, 4, 5, and 6 are alert-only modes.

Mode 7 is a warning-only mode.

Terrain alerting and display functions are both warning and alert modes.

MODE		ALERTS		WARNINGS			
CONDITION	NO.	AURAL	GND PROX G/S INHIBIT LIGHT	AURAL	PFD	ND	MASTER WARNING LIGHTS
EXCESSIVE DESCENT RATE	1	X	X	X	X		X
EXCESSIVE CLOSURE RATE WITH RESPECT TO RISING TERRAIN	2	X	X	X	X		X
LOSS OF ALTITUDE AFTER TAKEOFF OR DURING GO AROUND	3	X	X				
TOO CLOSE TO TERRAIN WHEN NOT IN LANDING CONFIGURATION	4	X	X				
EXCESSIVE DEVIATION BELOW GLIDE SLOPE	5	X	X				
RADIO ALTITUDE CALLOUTS	6	X					
WINDSHEAR	7			X	X		X
TAAD CAUTION		X	X			X	
TAAD WARNING			X	X	X	X	X

Figure 3 GROUND PROXIMITY MODES

COMPONENT LOCATIONS - 1

The GPWS components in the flight deck are:

- Ground proximity warning computer circuit breaker
- GPWS warning module

The interface components are:

- Captain’s and first officer’s aural warning speakers
- Captain’s and first officer’s master warning lights
- Left and right outboard IDUs
- Left and right inboard IDUs
- Lower IDU

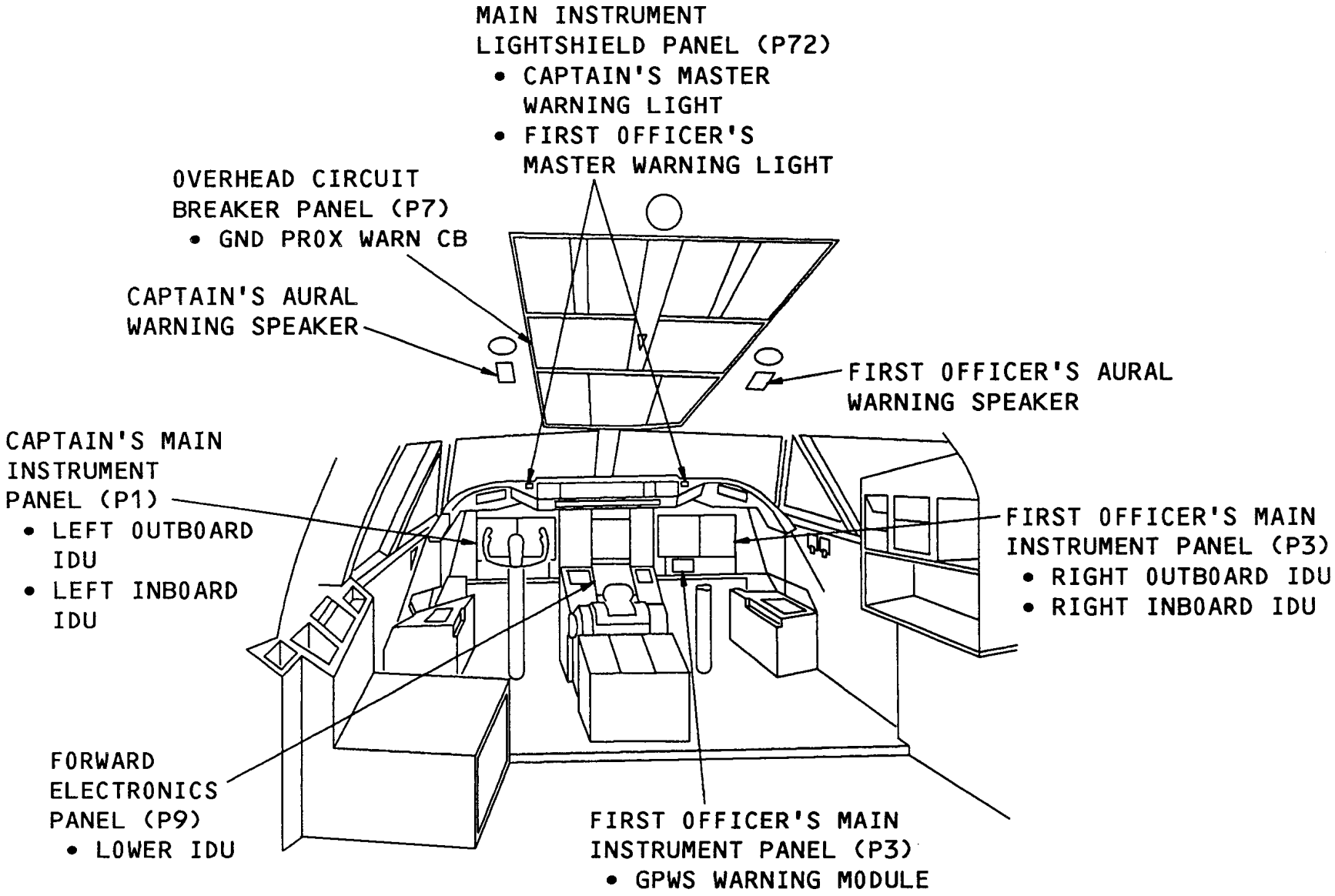

Figure 4 COMPONENT LOCATIONS - 1

COMPONENT LOCATIONS - 2

The ground proximity warning computer is located in the main equipment center.

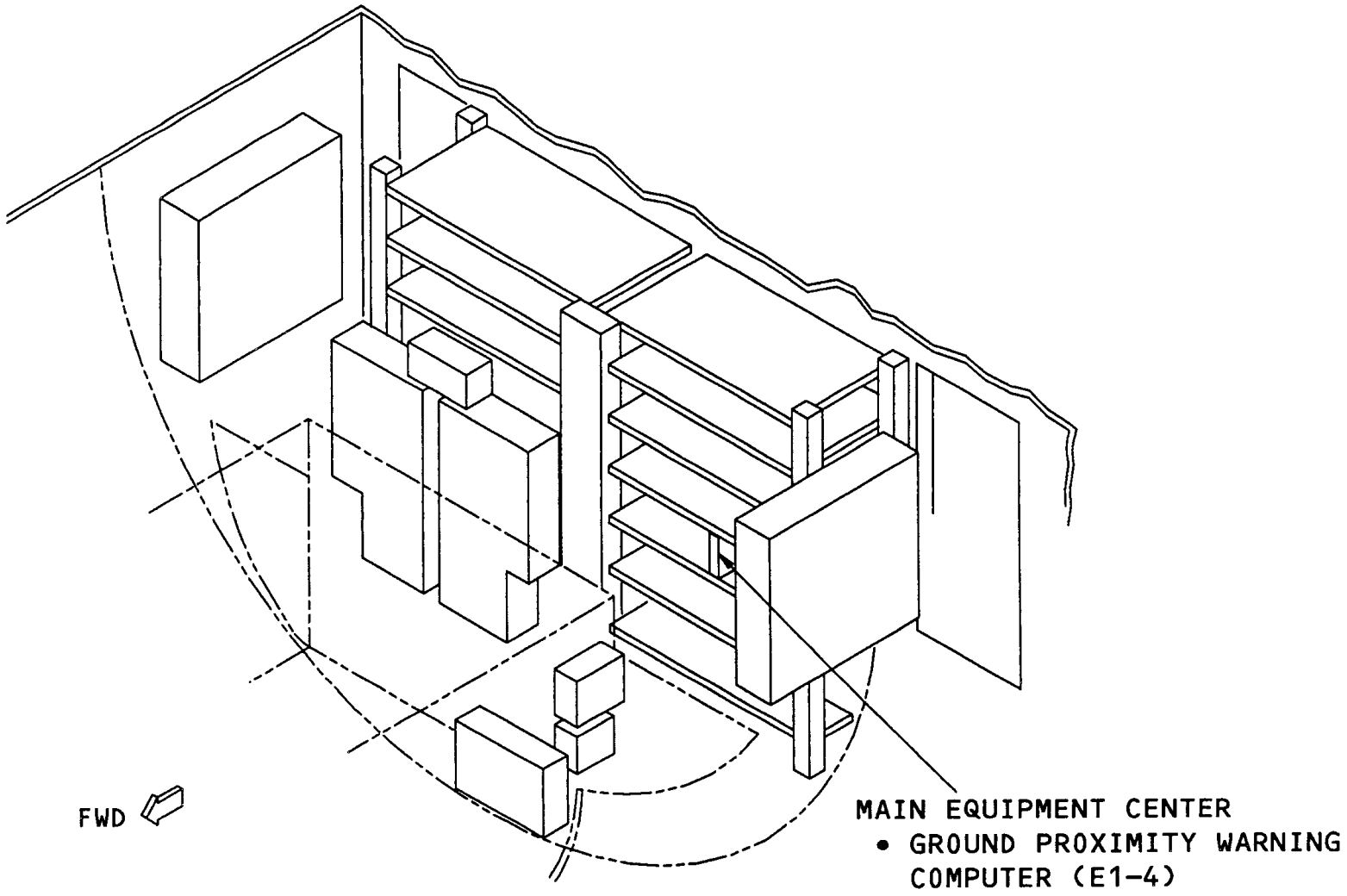

Figure 5 COMPONENT LOCATIONS - 2

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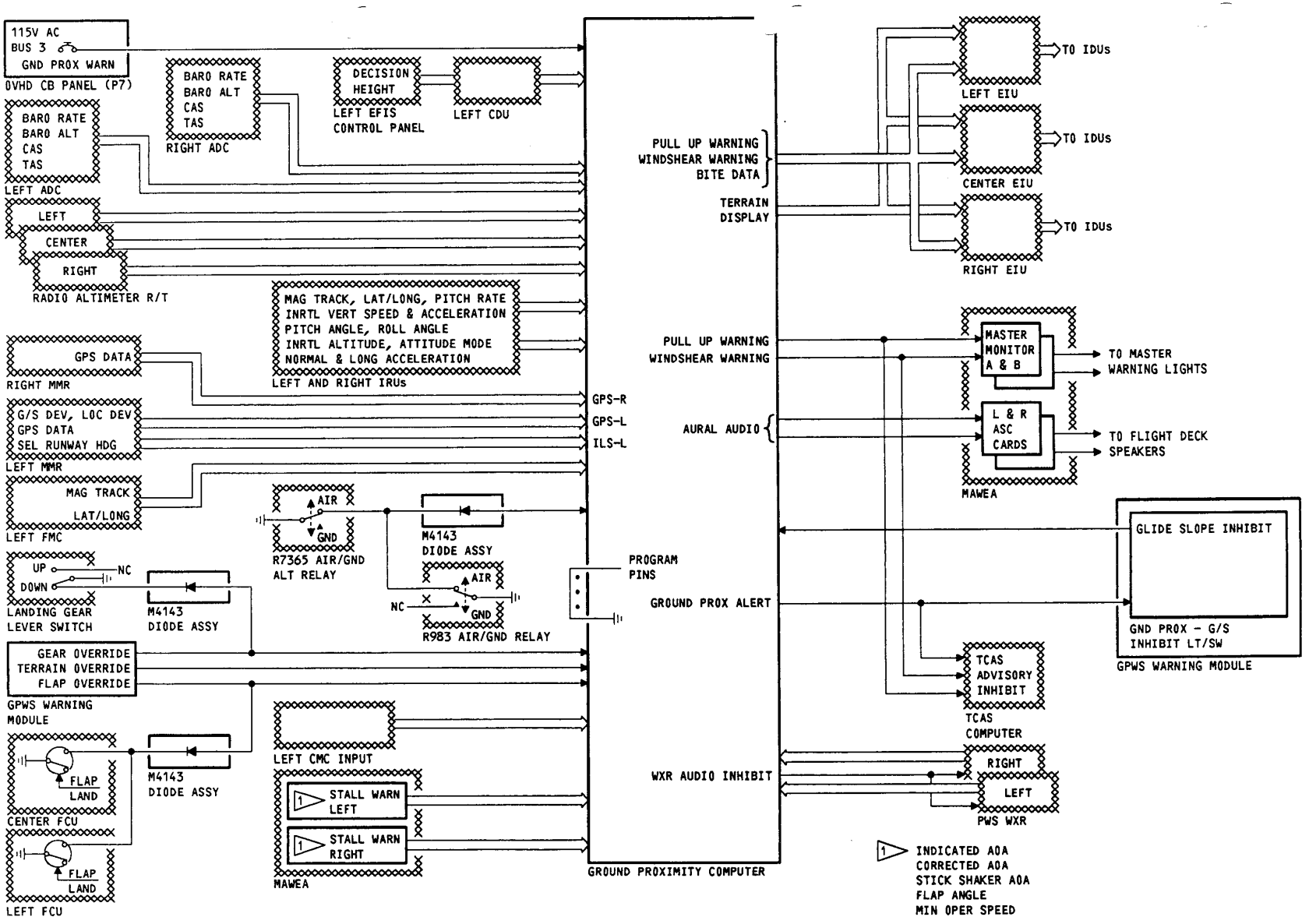


Figure 6 GPWS – INTERFACE DIAGRAM

GPWS - ARINC 429 INPUTS

Radio Altimeter (RA)

All three radio altimeters supply radio altitude.

The primary source is the L RA. If the L RA fails then the GPWC defaults to the C RA. If both L RA and C RA fail then the GPWC defaults to the R RA.

The GPWC also compares RA inputs. If the left RA is within 500 feet of the center or right RA then the GPWC uses the left RA. If the left RA fails the comparison, the GPWC will use the center RA if it is within 500 feet of the right RA. If both the left and center RAs fail the comparison, the GPWC will use the left RA.

Air-Data Computer (ADC)

The input from the L ADC supplies:

- Computed airspeed
- True airspeed
- Baro altitude
- Baro corrected altitude
- Baro altitude rate

Instrument Landing System (ILS)

The L ILS receiver supplies:

- Glide slope deviation
- Localizer deviation
- Selected runway heading

Flight Management Computer (FMC)

The L FMC supplies:

- Latitude
- Longitude
- Magnetic track

The primary source is the L FMC. If the L FMC fails, the GPWC defaults to the L IRU.

Inertial Reference System (IRS)

The left inertial reference unit (L IRU) supplies:

- Latitude
- Longitude
- Magnetic track
- Inertial vertical speed

Inertial Reference System (IRS) (cont)

- Inertial altitude
- Pitch angle
- Roll angle
- Pitch rate
- Normal acceleration
- Longitudinal acceleration
- Inertial vertical acceleration
- Attitude mode

EFIS Control Panel/Control Display Unit (EFIS CP/CDU)

The left EFIS CP/CDU supplies decision height.

MAWEA

The left and right stall warning cards supply:

- Indicated AOA
- Corrected AOA
- Stick shaker AOA
- Flap angle
- Minimum operating speed

The left stall warning card is the primary source. If it fails, the GPWC defaults to the right stall warning card.

Central Management Computer (CMC)

The L CMC supplies:

- CDU ground test commands
- CDU confidence test commands
- Status requests

Data Utilization

The matrix on appendix 1 COMPUTATION DATA SOURCES at the end of this course shows the utilization of the various parameters.

Global Positioning System (GPS)

The left and right multi-mode receivers (MMRS) send this GPS data:

- Latitude
- Longitude
- Altitude
- Vertical Speed
- Date
- Time (UTC)
- Ground Speed
- True Track
- GPS data integrity figure
- GPS sensor status.

Weather Radar (WXR)

The WXR receiver transmitters (RTs) send predictive windshear (PWS) data to the GPWC to inhibit lower priority GPWS alerts.

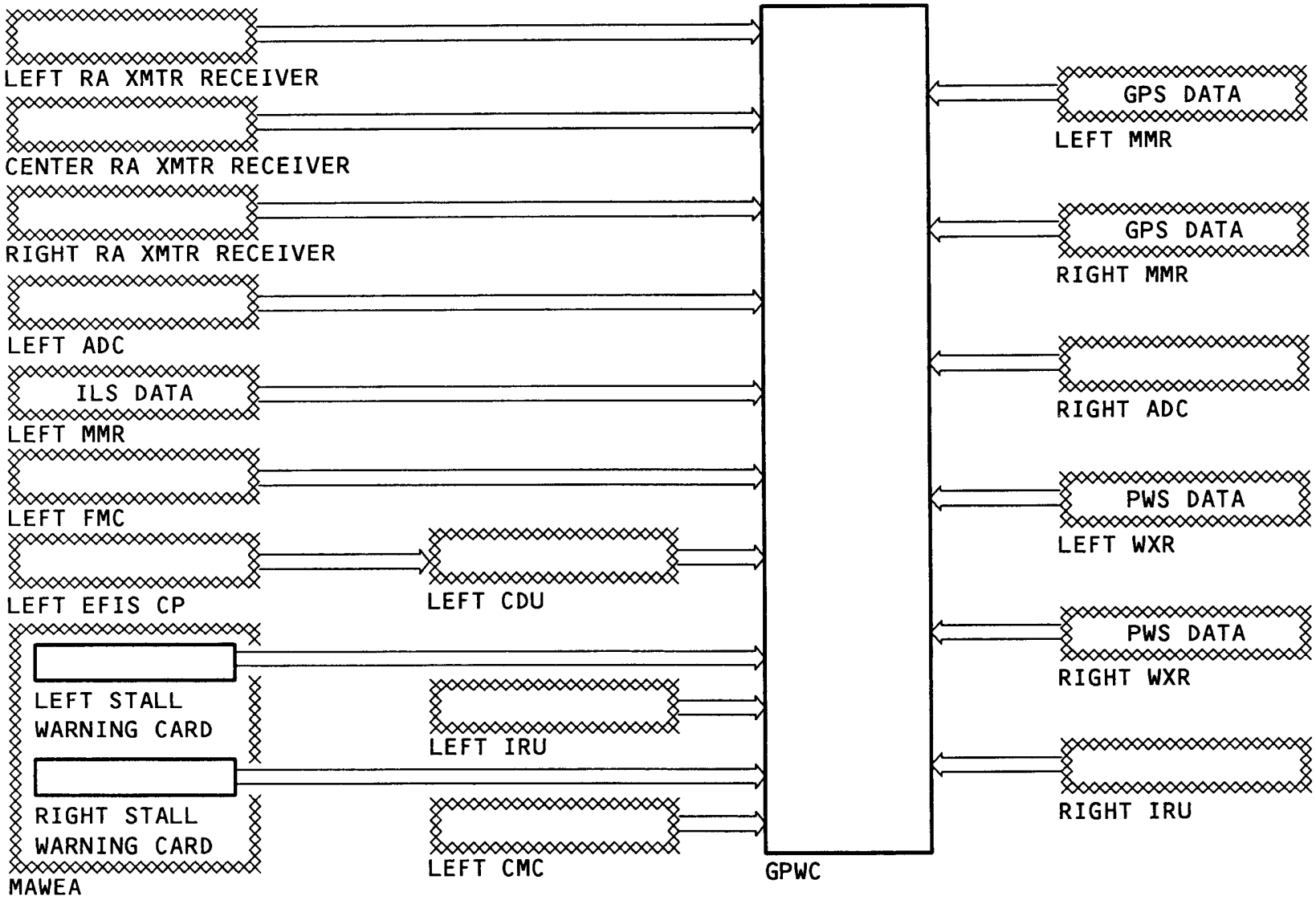


Figure 7 ARINC 429 INPUTS

GPWS - ANALOG INPUTS

Power

Power is 115v ac from the overhead circuit breaker panel.

Air/Ground Discrete

The input from the air/ground relays along with computed airspeed and radio altitude determine an in air or on ground condition, which:

- Disables mode annunciations on the ground
- Disables the flight deck tests in flight
- Defines flight leg beginning and end in the fault memory, if the CMC is unable to do so.

Glide Slope Inhibit Discrete

The glide slope inhibit discrete from the GND PROX-G/S INHB light/switch on the GPWS warning module inhibits or cancels mode 5.

Landing Flap Position

The computation of some modes includes landing flap position. The source of the landing flap discrete is the center or left flap control unit. This signal indicates one of two states:

- Flaps up for flaps at 20 or less
- Flaps down for flaps at 25 or 30

The flap override switch on the GPWS warning module simulates a flap down position.

Landing Gear Position

The computation of some modes also includes landing gear lever position. The source of the landing gear discrete is the landing gear lever switch.

The configuration/gear override switch on the GPWS warning module simulates a gear down position.

Terrain Override Switch

Pressing the terrain override switch (TERR OVRD) overrides the terrain clearance floor (TCF) and terrain awareness alerting and display (TAAD) features. GPWS modes 1-7 will continue to function after the TCF and TAAD features are inhibited by this switch.

Program Pins

GPWC program pins define various options available to the airlines.

The program pins are read when the GPWC is powered ON. The program pin configuration determines parameters such as:

- Airplane type
- Mode 6 altitude callouts
- High or low audio volume.

The program pin common is inside the GPWC.

Terrain Relay Monitor

The terrain relay monitor gives the GPWC the position of the Capt and FO terrain relays and shows if the actual relay position matches the commanded position.

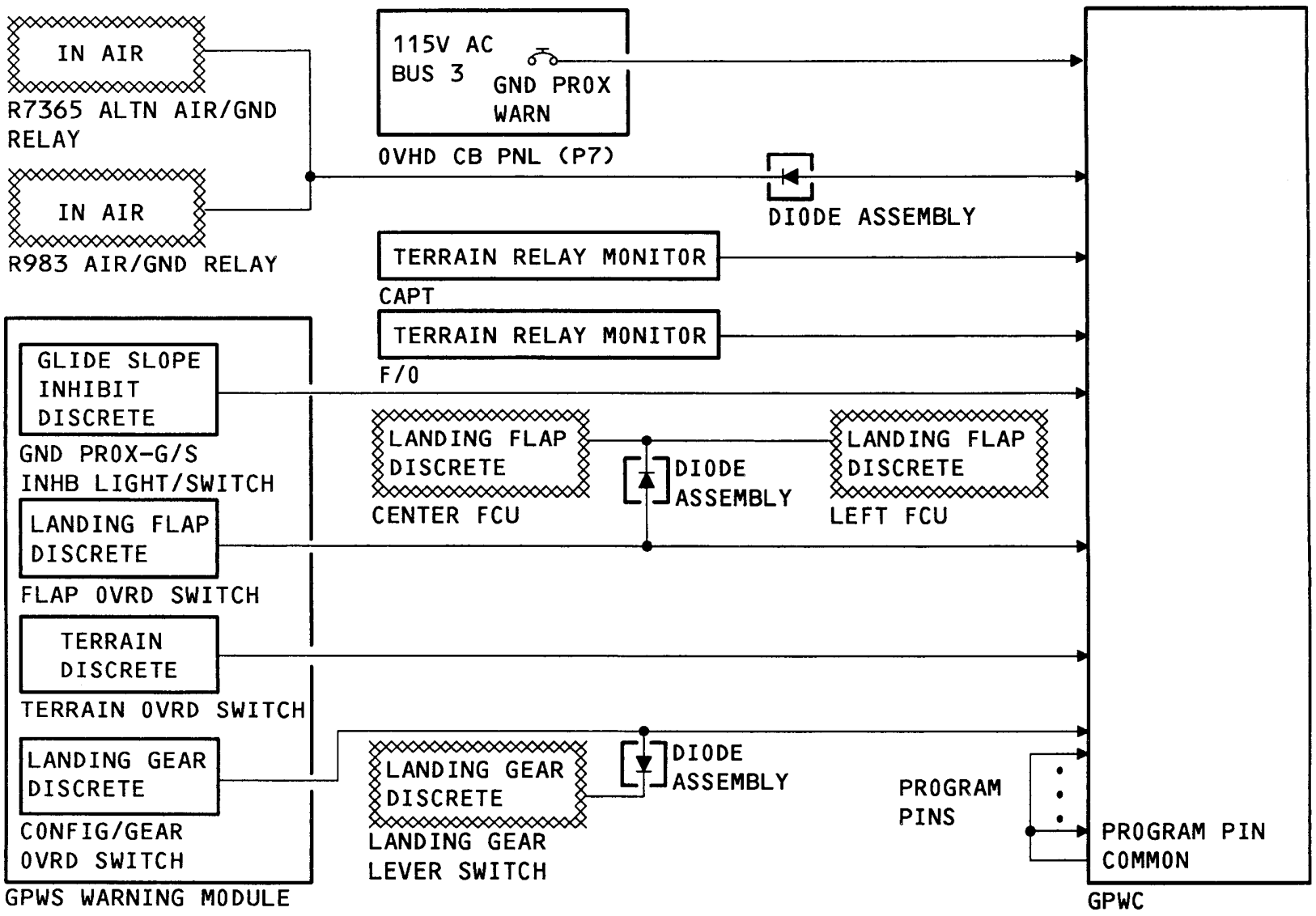


Figure 8 GPWS - ANALOG INPUTS

GPWS - ANALOG OUTPUTS

GPWC Analog Output Signals

The analog output signals are:

- Aural annunciations
- PULL UP warning discrete (modes 1 and 2)
- WINDSHEAR warning discrete (mode 7)
- Modes 1 thru 5 alert discrete
- Glide slope cancel discrete
- Aural prioritization discretes
- Terrain display discretes.

The GPWC produces the aural annunciations. The synthesizer cards in the MAWEA amplify them.

The pull up warning, windshear warning, and alert discretes go to the TCAS (traffic alert and collision avoidance system) computer to inhibit lower priority TCAS alerts.

Aural prioritization discretes go to TCAS and the weather radar to inhibit lower priority aural alerts.

MAWEA Outputs

The MAWEA transmits its outputs in this way:

- Aural annunciations from the left aural synthesizer card to the captain's aural warning speaker.
- Aural annunciations from the right aural synthesizer card to the first officer's aural warning speaker.
- Discretes from both master monitor cards to both master warning lights.

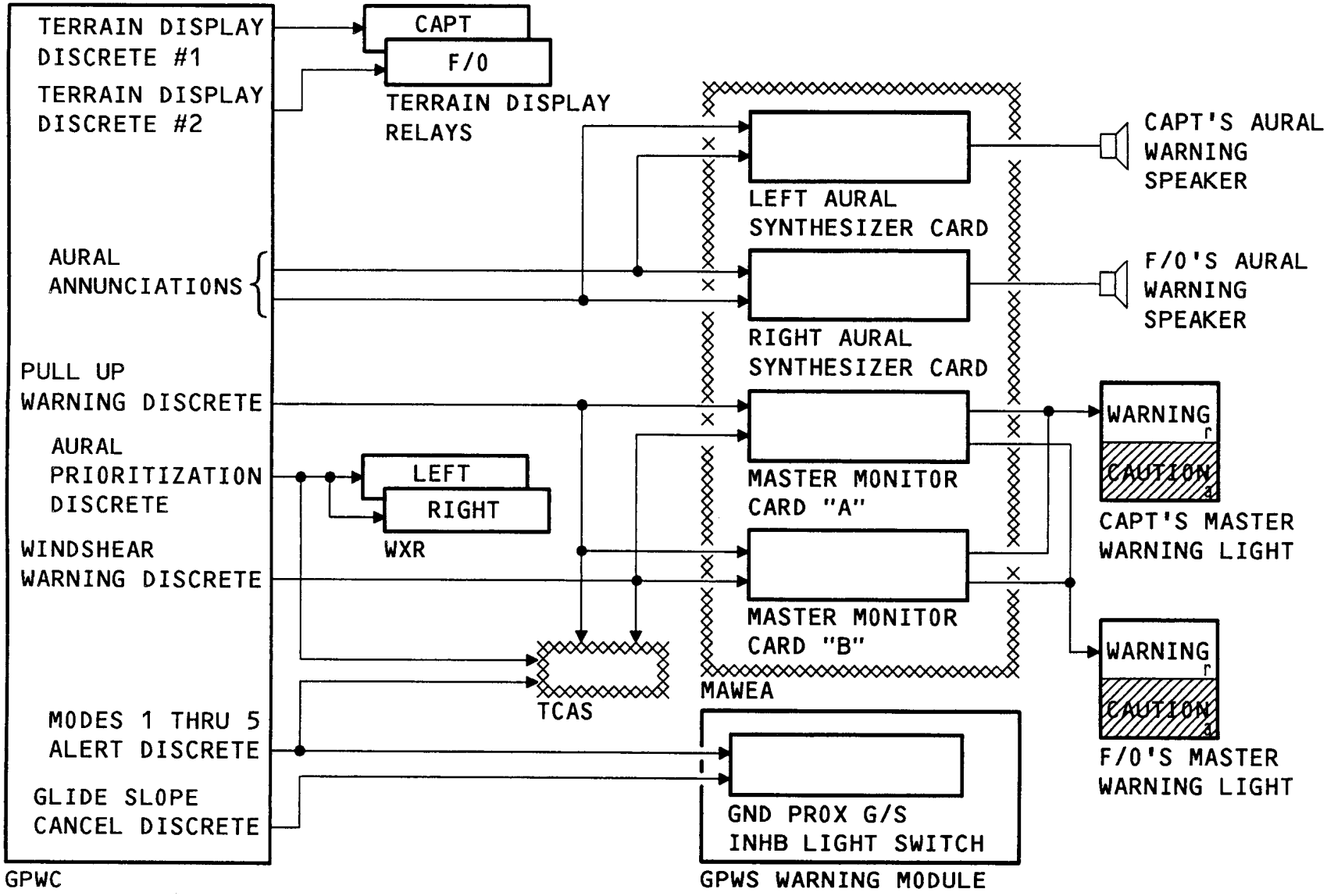


Figure 9 GPWS - ANALOG OUTPUTS

GPWS - DIGITAL BUS OUTPUTS

ARINC 429

The ARINC 429 outputs from the GPWC are:

- Pull-up warning (modes 1 and 2)
- Windshear warning (mode 7)
- GPWS status (GPWS function failure)
- Windshear status (windshear function failure)
- Status data for the CMC

The EFIS/EICAS Interface Units (EIUs) receive the above ARINC 429 DATA and then transmit the signals to the primary flight displays, EICAS displays and CMCs.

ARINC 453

Terrain display data is sent on two high speed ARINC 453 data buses from the GPWC. These data buses go to the terrain switching relays along with weather radar (WXR) display data. Either terrain or WXR data is sent to the navigation displays. Logic in the

GPWC controls the position of the terrain switching relays.

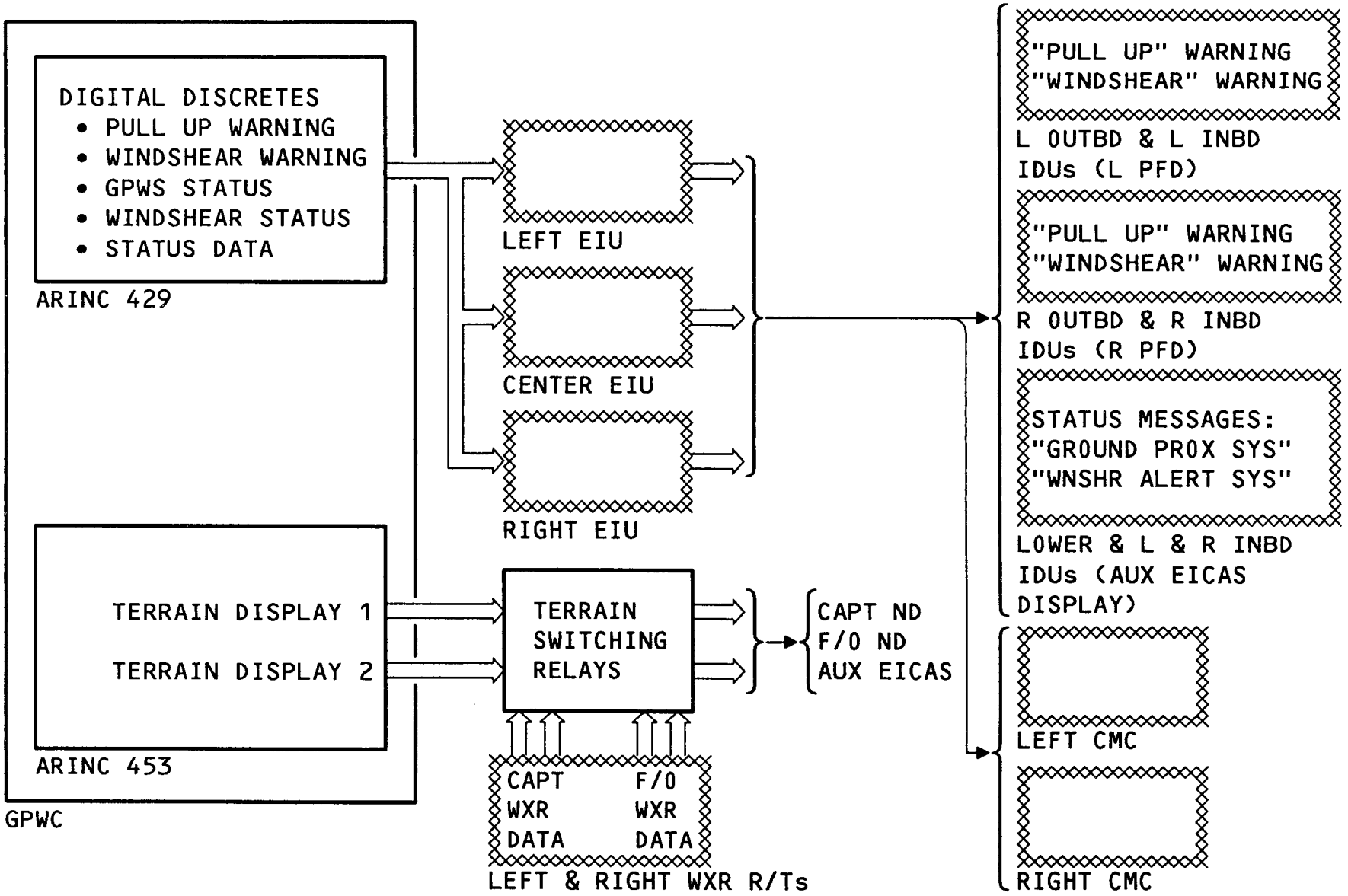


Figure 10 GPWS - DIGITAL BUS OUTPUTS

GROUND PROXIMITY WARNING COMPUTER

Purpose

The ground proximity warning computer (GPWC) compares the airplanes flight profile, flap and gear position, and terrain clearance to determine if an alert condition exists.

Description

The enhanced GPWS function contains a worldwide terrain database. It compares airplane position, track and speed with this database to determine if an alert condition exists. Terrain data displays on the navigation displays (NDs).

The enhanced GPWS function also contains an airport database. This database contains terrain information about all hard surface runways 3500 feet or more in length. GPWS compares airplane position and runway location to determine if an alert condition exists.

Physical Description

The ground proximity warning computer (GPWC) is a two MCU chassis and weighs seven pounds. The GPWC requires no forced cooling air.

Front Panel

The GPWC front panel has three status LEDs and a door.

These are the three status LEDs on the front panel:

- EXTERNAL FAULT - amber LED turns on for a failure external to the GPWC.
- COMPUTER OK - green LED stays on when GPWC has power and operates normally.
- COMPUTER FAIL - red LED turns on when the GPWC has an internal failure.

Front Panel (cont)

The front panel door allows access to the following:

- PRESS TO SELF TEST switch - begins a test of the GPWS
- Headphone jack - allows you to hear self test audio
- Memory card slot - allows you to upload software from a memory card, or download fault and warning history data
- Upload/download status indicators displays conditions of upload or download operation
- RS-232 connector - used for shop test, or for the upload/download of data.

Voice Menu Configuration

Several aural message configurations are available. Selection of the desired configuration is by grounding the appropriate program pins.

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.

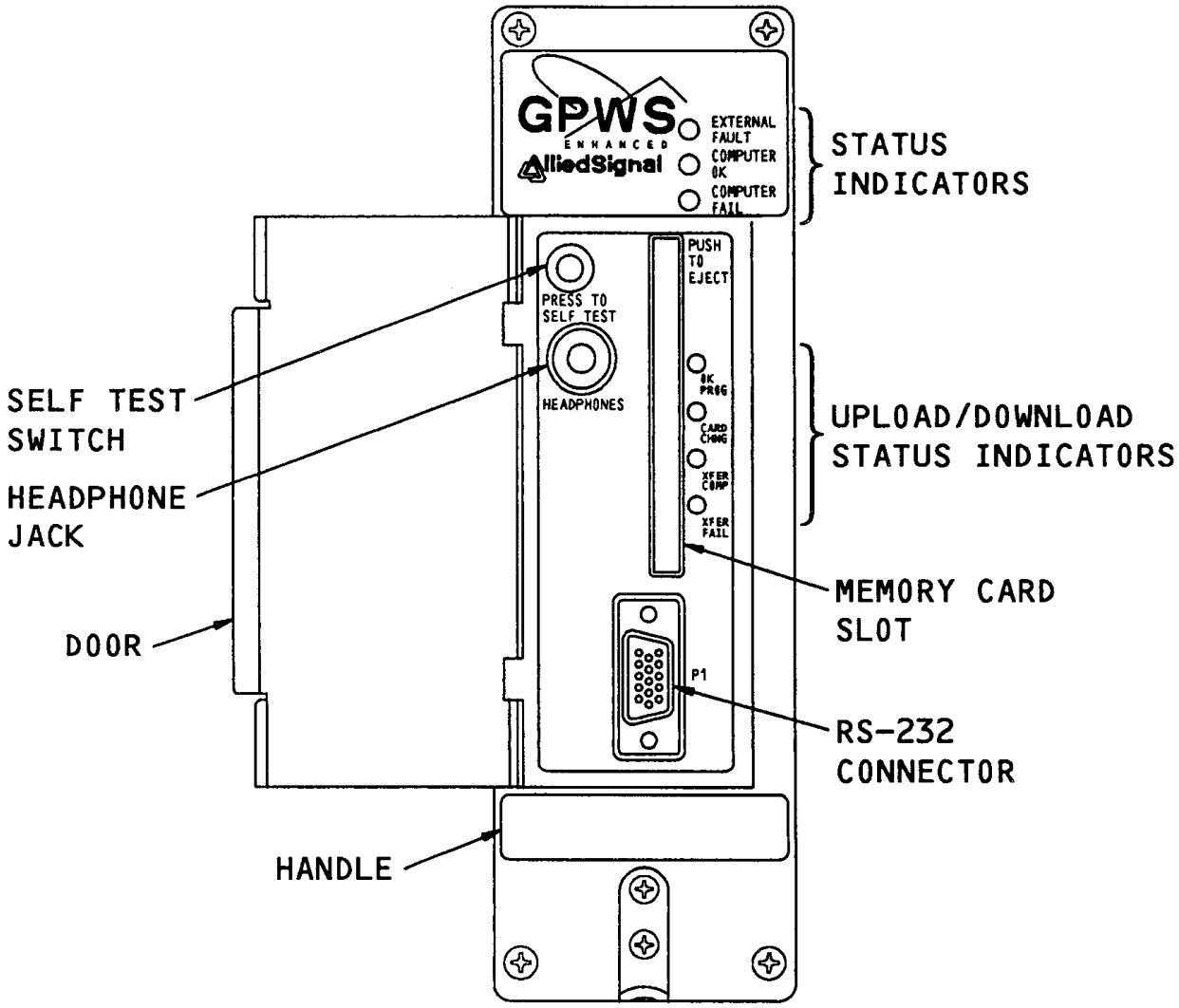


Figure 11 GROUND PROXIMITY WARNING COMPUTER

GPWS - CONTROL COMPONENTS

Description

The GPWS warning module contains the system control components. It is a selfcontained unit and therefore it is a Line Replaceable Unit (LRU). The module contains these controls:

- A ground proximity glide slope inhibit light/switch
- A ground proximity flap override switch
- A ground proximity configuration/gear override switch
- Terrain override switch.

GND PROX - GIS INHB Light/Switch

The GND PROX-G/S INHB light/switch has two functions:

- The GND PROX light shows ground proximity alerting for modes 1 through 5.
- Push the switch to inhibit or cancel mode 5 (below glide slope) visual and aural alerts.

If the operator pushes the switch before the mode 5 indications start, then mode 5 is inhibited. If the operator pushes the switch after the indications have started, then all mode 5 indications are cancelled. After this inhibit or cancel action, a second push of the switch cannot re-start mode 5. To reset mode 5, the airplane must descend below 30 ft or ascend above 1000 ft RA.

Flap and Gear Override Switches

The GND PROX FLAP OVRD switch and the GND PROX CONFIG GR OVRD switch simulate flaps down 25 units or more and landing gear down positions. These are guarded alternate-action pushbutton switches.

In the ON position the switches illuminate.

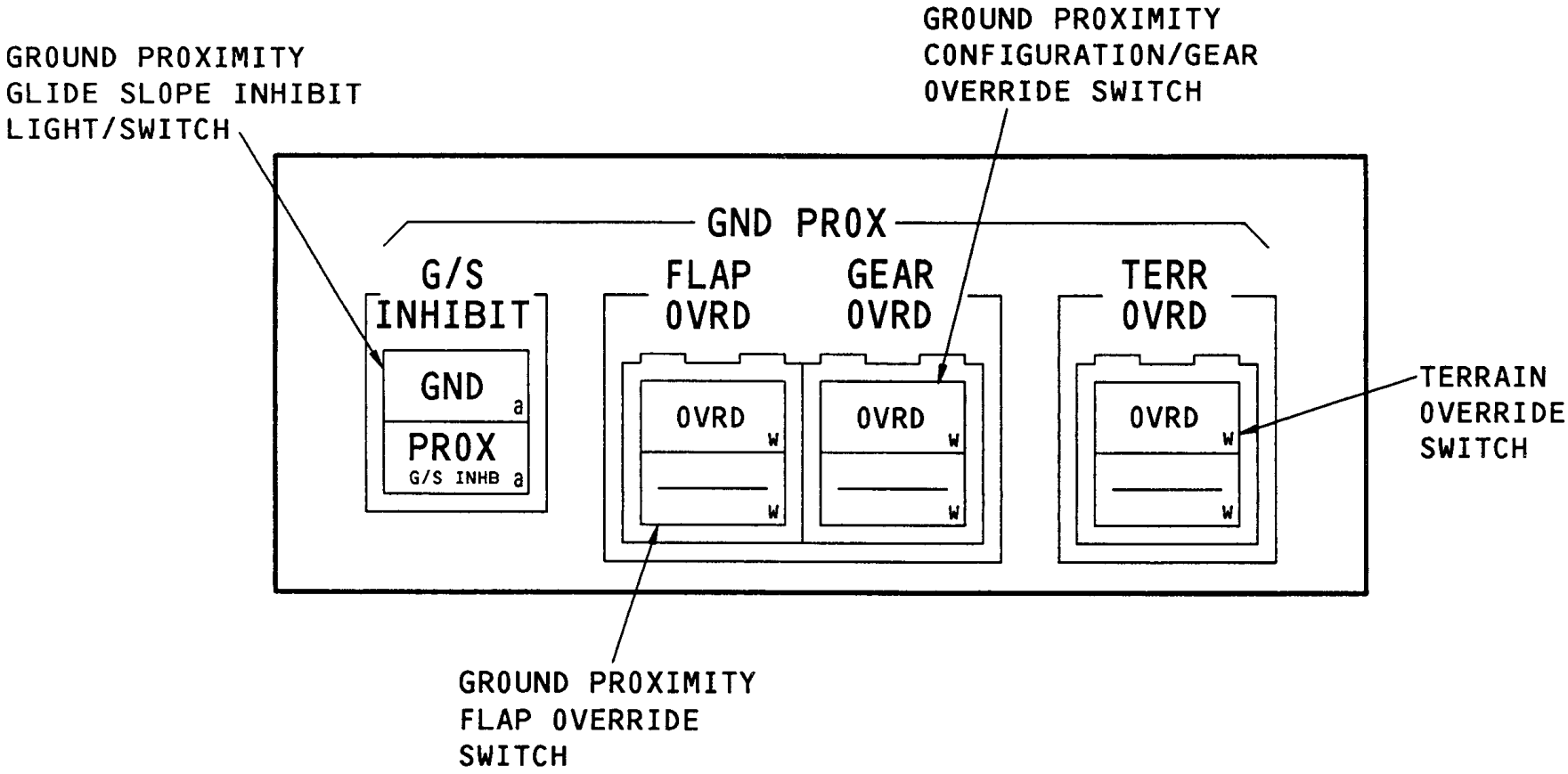
Terrain Override Switch

Push the TERR OVRD switch to inhibit the terrain clearance floor (TCF) and terrain awareness and alerting display (TAAD) functions of the GPWS. The basic modes (modes 1-7) of the GPWS are not affected by this switch.

The flight crew uses the terrain override switch for any of the following conditions:

- The crew determines position data is not valid.
- A terrain awareness alert shows when it is obvious no terrain threats exist.

CAUTION: CAREFULLY SLIDE GROUND PROXIMITY WARNING MODULE OUT OF INSTRUMENT PANEL TO AVOID STRESS AND/OR DAMAGE TO ELECTRICAL CABLE AT REAR OF THE GROUND PROXIMITY WARNING MODULE.



GPWS WARNING MODULE

Figure 12 GPWS - CONTROL COMPONENTS

PFD & MASTER WARNING LIGHT ANNUNCIATIONS

PFD Warning Annunciations

The red PULL UP annunciation on the PFD indicates a mode 1 warning or a mode 2 warning.

The red WINDSHEAR annunciation on the PFD indicates a mode 7 warning.

Master Warning Lights

The captain's and first officer's master warning lights illuminate during the PULL UP and WINDSHEAR warnings.

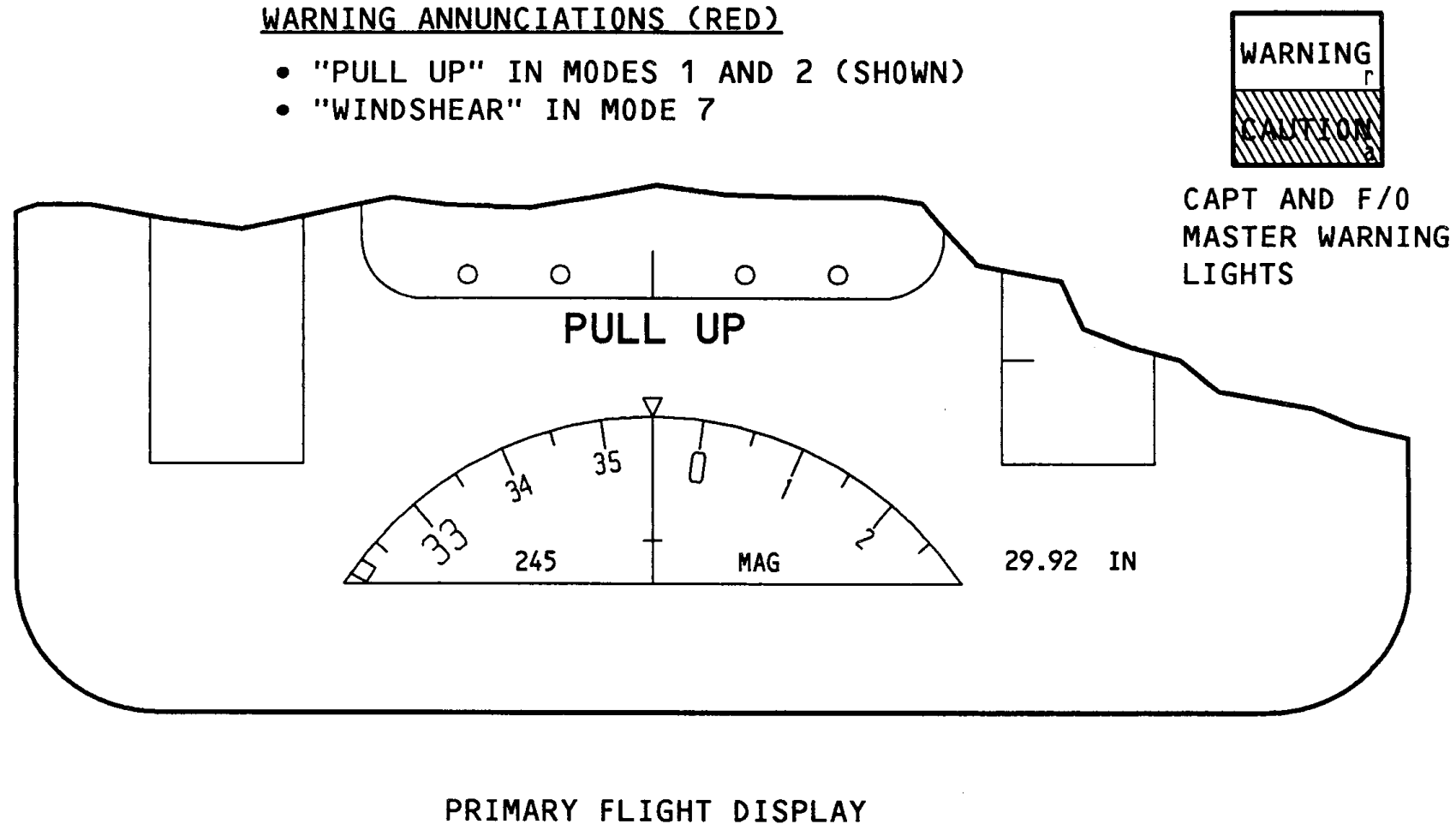


Figure 13 PFD & MASTER WARNING LIGHT ANNUNCIATIONS

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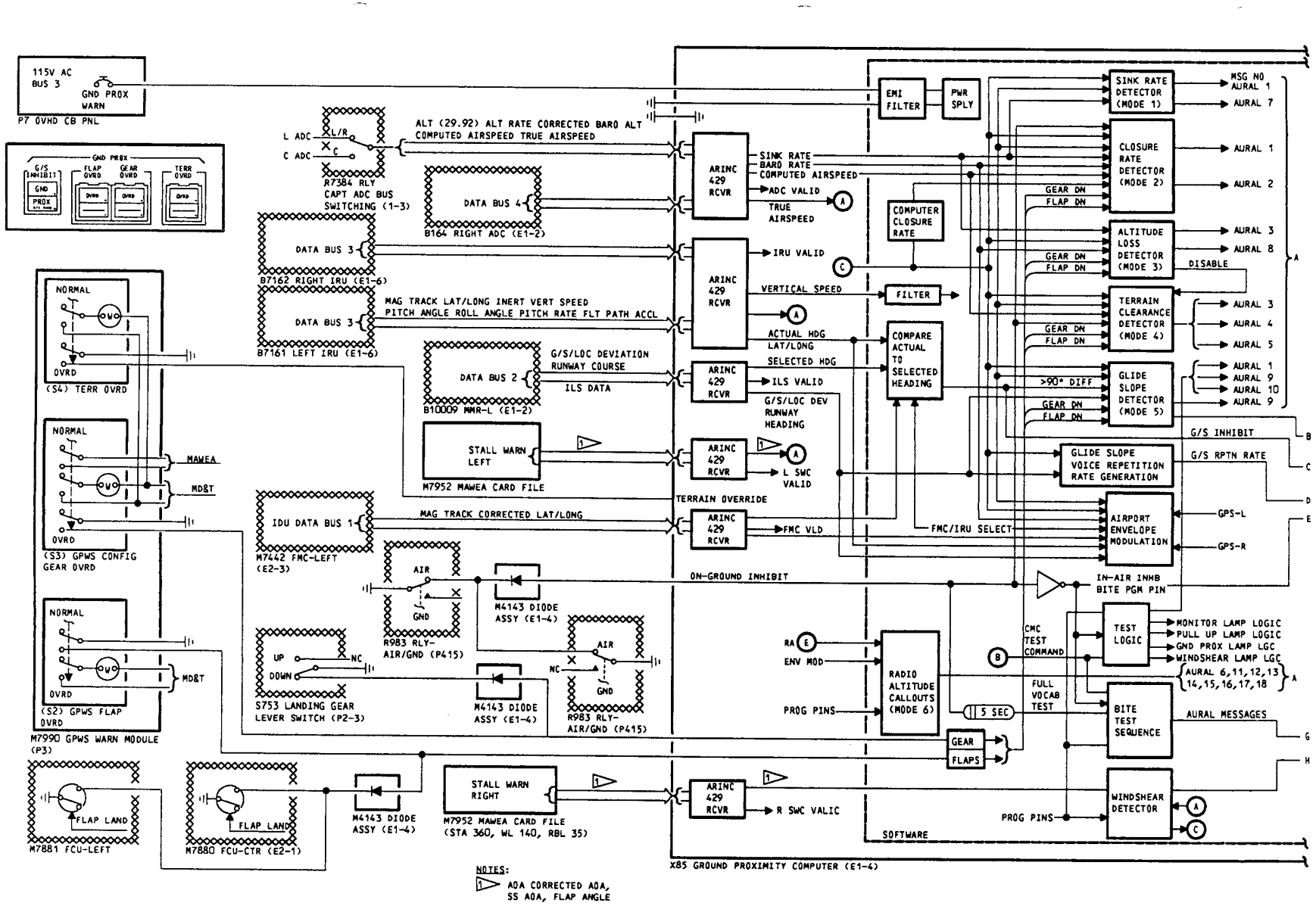

Figure 14 GPWS SCHEMATIC –1

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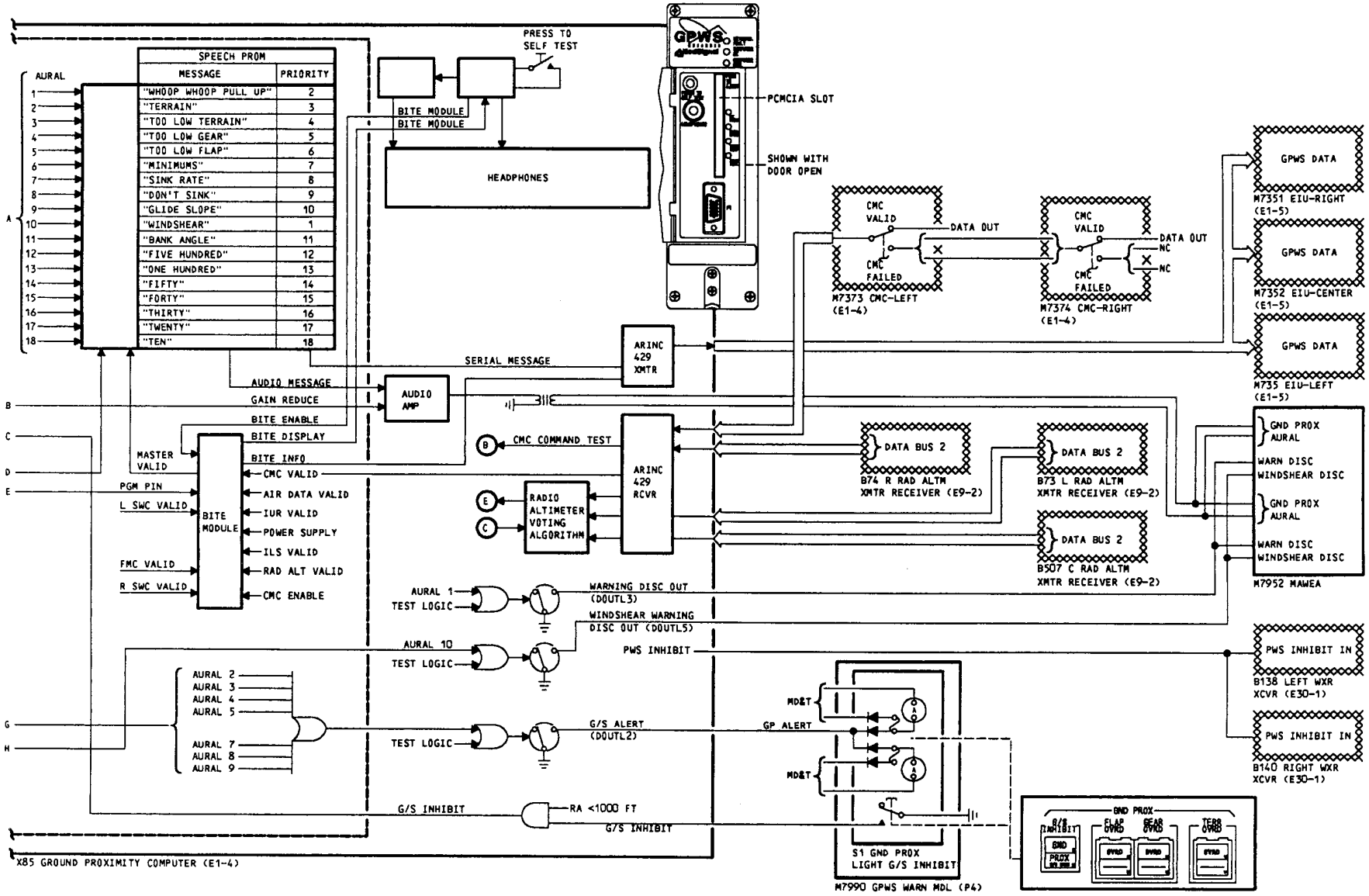

Figure 15 GPWS SCHEMATIC – 2

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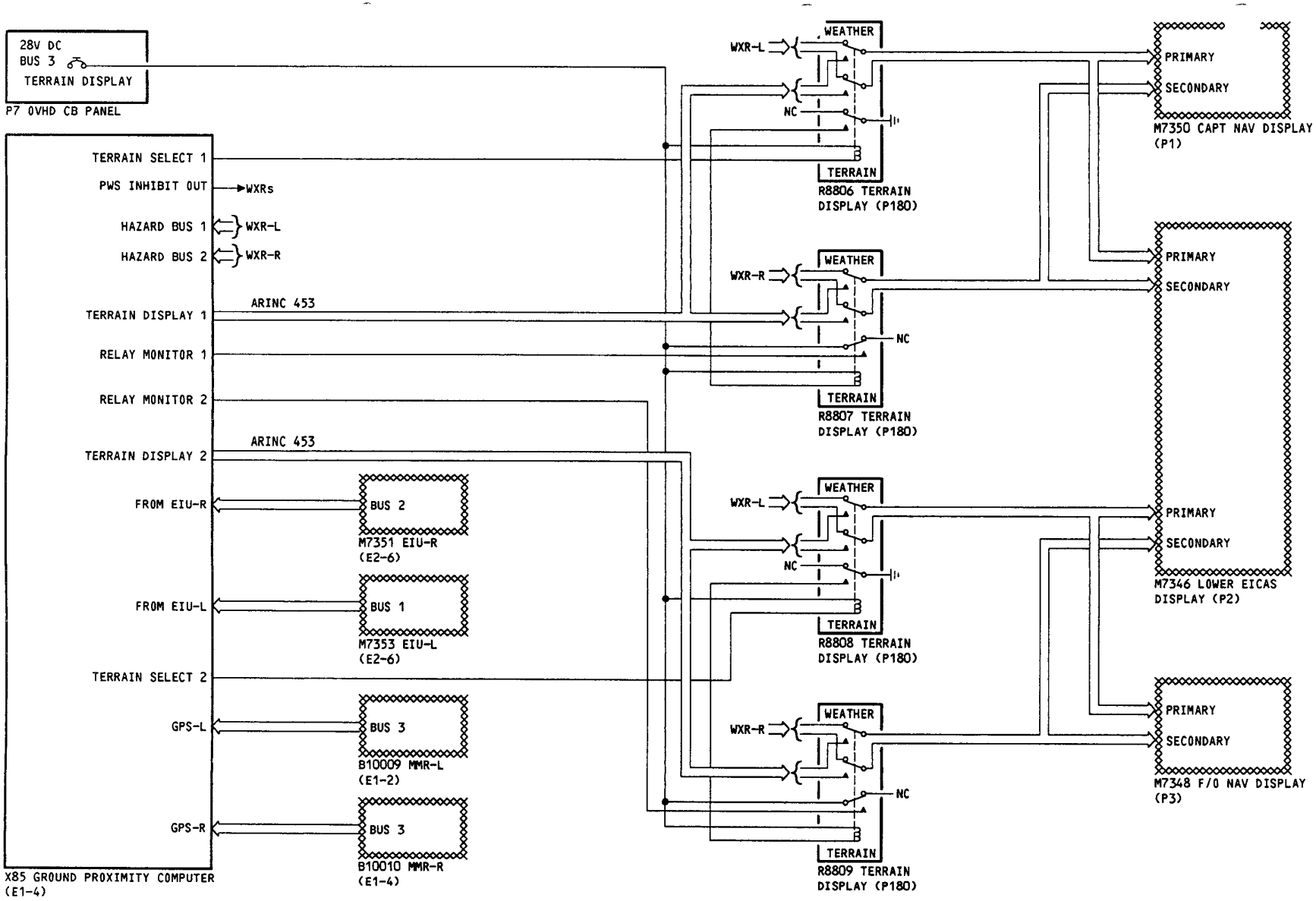


Figure 16 GPWS SCHEMATIC – 3

MODE 1 DESCRIPTION

Mode 1 Definition

Mode 1 supplies alerts and warnings of a large descent rate with respect to terrain clearance.

Mode 1 Thresholds

The threshold of annunciations varies with descent rate. The threshold value is 2450 ft RA for descent rates of 5007 feet per minute (FPM) and greater.

For lower descent rates the threshold value is lower.

At 30 ft RA, there are no annunciations if the descent rate is less than 998 FPM.

The lower boundary of annunciation is 30 ft.

This mode functions independently of landing gear and flap positions.

Mode Annunciations

Mode 1 includes two levels of annunciations:

- An alert
- A warning.

The alert consists of these indications:

- The GND PROX-G/S INHB light/switch shows
- The aural message ”sink rate .... 11 is repeated.

To prevent nuisance alerts during an ILS approach, the initial envelope will be modified when the airplane is above the Glide Slope. The amount of linear modification will be 0 FPM when on Glide Slope to a maximum of 300 FPM when the airplane is 2 dots above Glide Slope.

If the descent rate does not decrease, the warning follows. The warning consists of these indications:

- The red PULL UP message on the PFDs
- The red master warning lights
- The aural message ”whoop whoop pull up...” is repeated.

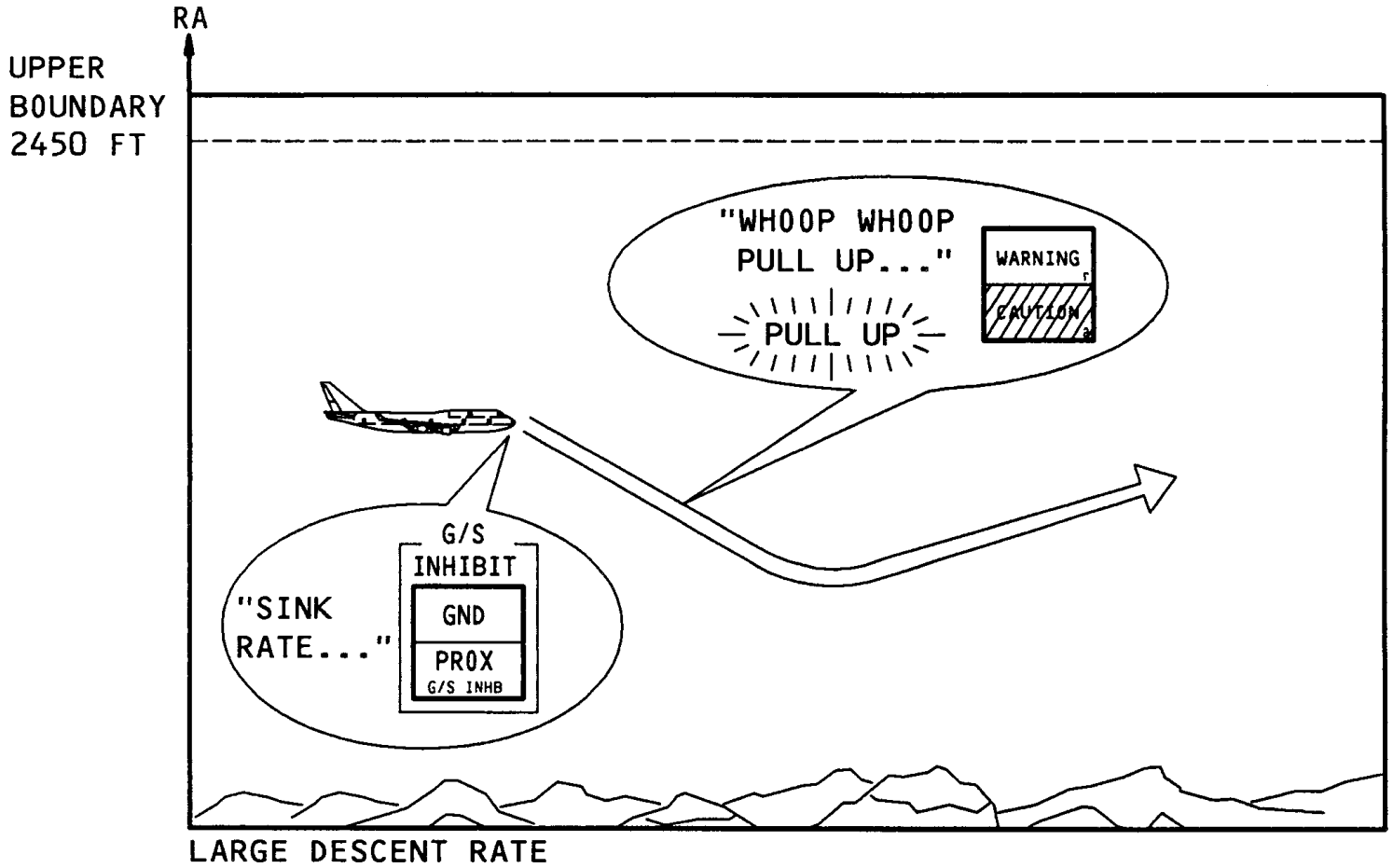


Figure 17 MODE 1 DESCRIPTION

MODE 1 OPERATION

Data Sources

The following LRUS supply these parameters.

Left, center or right radio altimeter supplies radio altitude

Left IRU supplies inertial vertical speed

Left ILS supplies glide slope deviation

Left or right ADC supplies baro altitude rate.

Inertial vertical speed is the primary parameter. If it is not available, the mode detector uses baro altitude rate.

Mode 1 Function

The mode 1 detector determines a presence of mode 1 and generates the required annunciations which are:

- A preliminary annunciation which is an alert
- A warning.

Alert Output

The AURAL-7 discrete starts the alert annunciations. It closes switch S1 which:

- Turns on the GND PROX-G/S INHB light/switch.
- Goes to the traffic alert and collision avoidance system (TCAS) to inhibit advisories.

It also goes to the speech prom which generates the aural SINK RATE.

Warning Output

The AURAL-1 discrete:

- Goes to the speech prom which generates the aural WHOOP, WHOOP PULL UP
- Closes switch S2 which causes the MAWEA to turn on the master warning lights and the TCAS to inhibit advisories
- Goes to the EIUs to show the red warning PULL UP on the PFDs.

Aural Output

The speech prom generates the aurals. The audio amplifier amplifies them and transmits them to the MAWEA via an output transformer. The MAWEA then sends them for transmission over the captain's and the first officer's aural warning speakers.

Mode Variations

The envelope modulation circuit supplies mode boundary variations at specific locations.

The BITE circuit supplies mode inhibit commands when circuit or input failures are present.

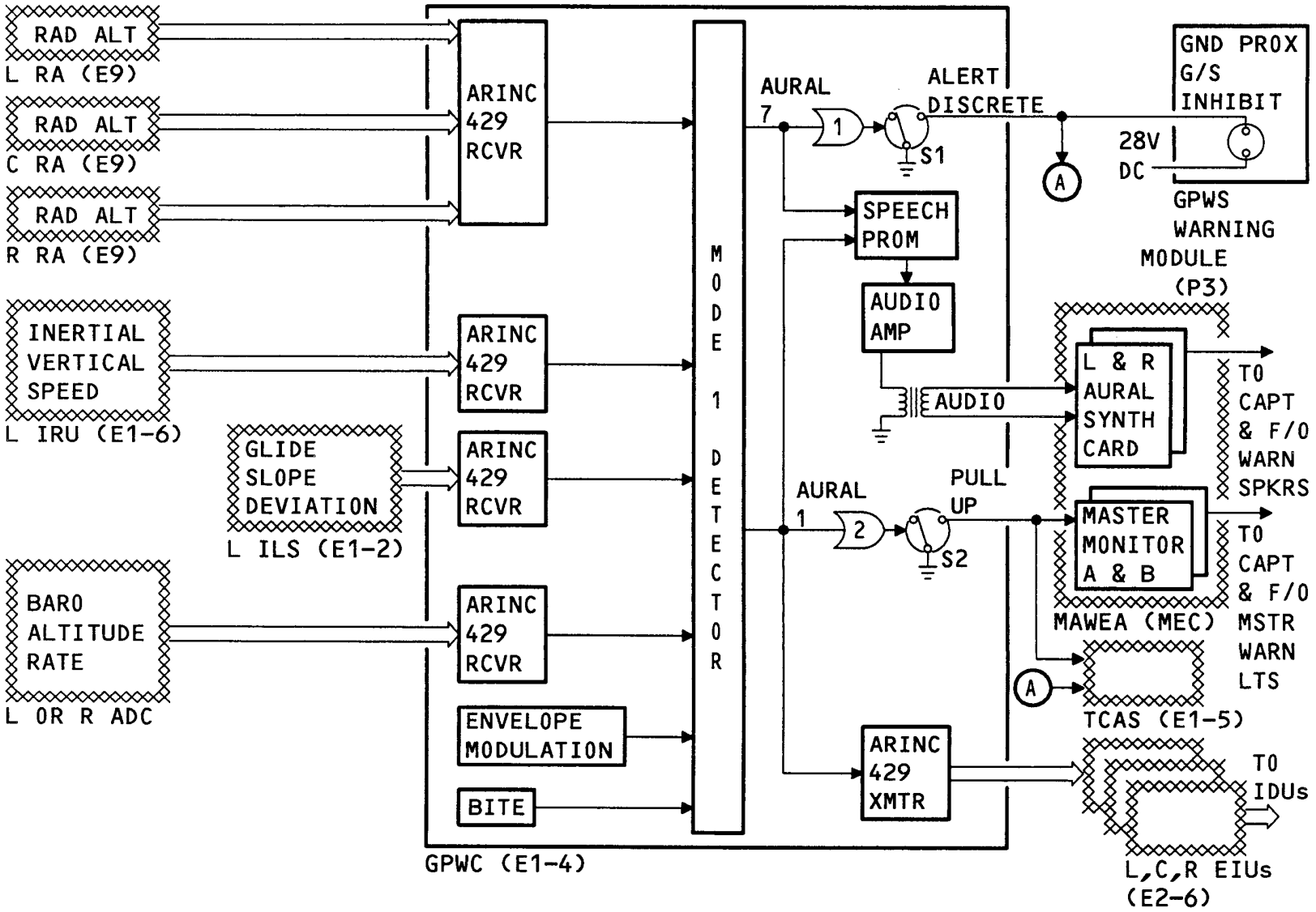


Figure 18 MODE 1 OPERATION

MODE 2A DESCRIPTION

Mode 2 Definition

Mode 2 supplies alerts and warnings for too large of a closure rate with respect to rising terrain. Mode 2 has two variations, 2A and 2B.

Mode 2A applies when the airplane is not in a landing configuration, that is if the flaps are 20 units or less and the glide slope deviation is greater than 2 dots.

Mode 2B applies when the airplane is in a landing configuration, that is if the flaps are 25 or 30 units, or if the airplane is on an ILS approach with glide slope deviation of 2.0 dots or less.

Mode 2A Thresholds

The threshold of annunciations varies with CAS and closure rate. These are typical threshold values:

- 2450 ft RA for CAS values of 310 knots (KTS) or greater and closure rates of 9800 FPM or greater
- 1650 ft RA for CAS values of 220 KTS or less and closure rates of 5733 FPM or greater.

The lower boundary of annunciations is 30 ft.

Mode 2A Annunciations

Mode 2A includes two levels of annunciations:

- - An alert - A warning.

The alert consists of these indications:

- The GND PROX-G/S INHB light
- The aural alert message ”TERRAIN, TERRAIN”.

After two alert messages, if the closure rate does not decrease, the warning follows.

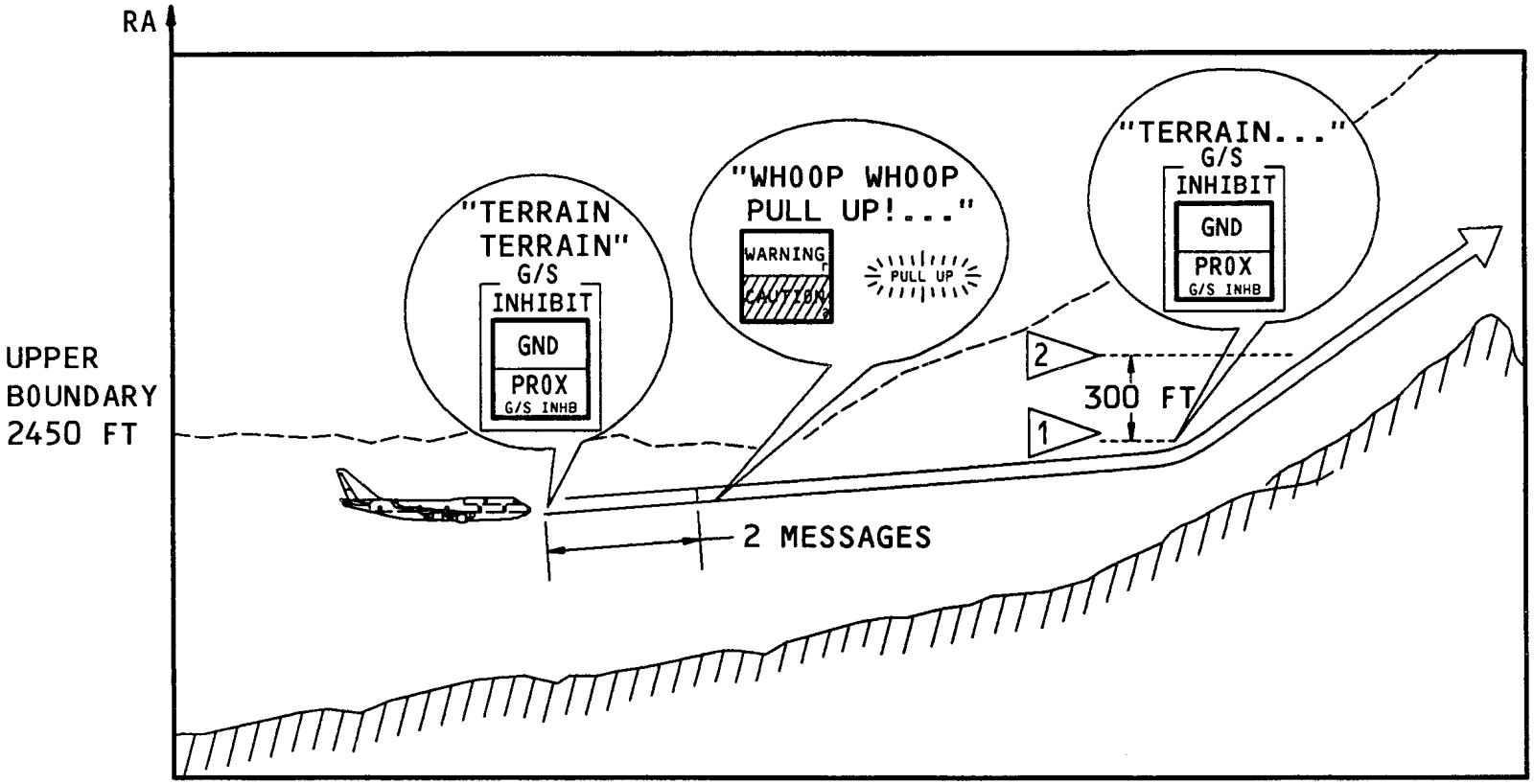
The warning consists of these indications:

- The red PULL UP message on the PFDs
- The red master warning lights
- The aural message ”WHOOP WHOOP PULL UP. . . 11 is repeated.

Altitude Gain Function

If the mode 2A warning envelope has been entered for more than 3 seconds and the sink rate condition has been corrected, the GPWC checks the landing gear position. If the gear is up, the altitude gain function is started. When the sink rate condition is corrected, the GPWC switches back to the 2A alert visual indications (GND PROX GIS INHB light) and shuts off the ”TERRAIN” aural as long as there is no further terrain closure. This alert indication will contiue until the airplane has gained 300 feet altitude up to a maximum of 45 seconds, or the landing gear is lowered.

If the gear is down the altitude gain function is inhibited.



TOO LARGE OF A CLOSURE RATE. AIRPLANE NOT IN LANDING CONFIGURATION, FLAPS <25 UNITS AND GLIDE SLOPE DEVIATION GREATER THAN 2.0 DOTS

ALTITUDE GAIN FUNCTION:

1 THE AURAL MESSAGE "WHOOP WHOOP PULL UP" CHANGES TO "TERRAIN..." WHEN THE AIRPLANE'S CLOSURE RATE DECREASES. IF WARNING WAS 3 SECONDS OR MORE, THE ALTITUDE GAIN FUNCTION IS ARMED.

2 IF TERRAIN FALLS AWAY THEN "TERRAIN" VOICE WILL SHUT OFF. THE GND PROX - G/S INHB LIGHT WILL REMAIN ON UNTIL 300 FT OF INERTIAL (BARO) ALT OR FOR A MAXIMUM OF 45 SECONDS. IF LANDING GEAR IS LOWERED THEN ALL ANNUNCIATIONS CEASE.

Figure 19 MODE 2A DESCRIPTION

MODE 2B DESCRIPTION

Mode 2B Annunciations

Mode 2B has two variations of annunciations:

- When the airplane is in landing configuration; gear and flaps down
- When the airplane is not in landing configuration; flaps or gear up, or both up.

Airplane in Landing Configuration

The annunciation has these indications:

- The aural TERRAIN, TERRAIN, is repeated
- The GND PROX-G/S INHB light.

Airplane Not in Landing Configuration

The annunciation shows this first:

- The aural TERRAIN, TERRAIN once
- The GND PROX-G/S INHB light.

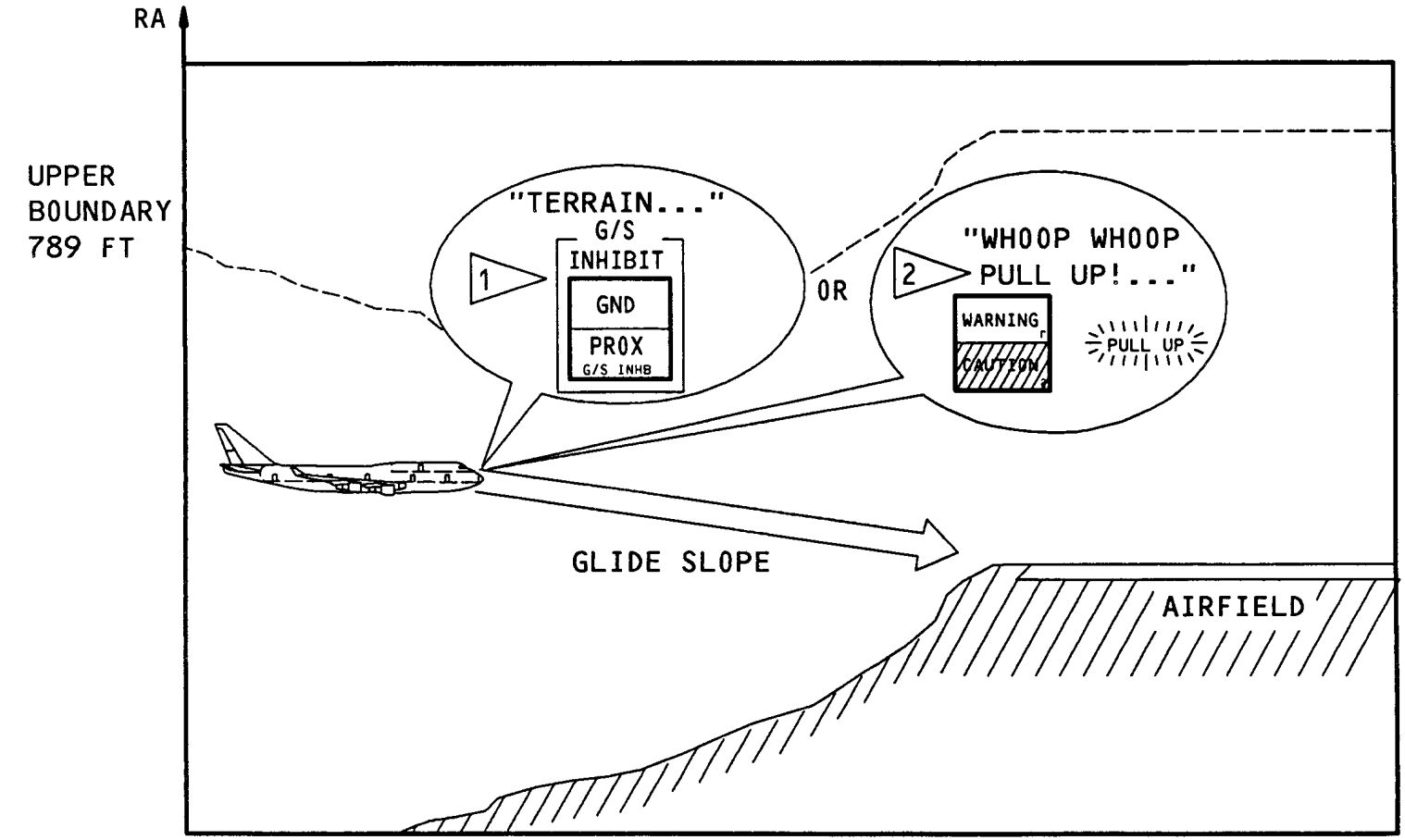
If the condition continues, the annunciation changes to this:

- The aural WHOOP, WHOOP PULL UP, is repeated
- The red PULL UP message shows on the PFDs
- The master warning lights show.

Mode 2B Thresholds

The threshold of annunciations varies with closer rate. It is 789 ft for closure rates of 3000 FPM or greater. For lower closure rates the threshold values are lower. For instance, for a closure rate of 2253 FPM the threshold value is 200 ft.

When the flaps are down, the lower boundary, at which the annunciations cease varies with descent rate. It is 200 ft for descent rates of 400 FPM and less, and 600 ft for descent rates of 1000 FPM or more. For descent rates between 400 FPM and 1000 FPM, the lower boundary varies linearly. When the flaps are up, the lower boundary is 30 ft.



TOO LARGE A CLOSURE RATE. AIRPLANE IN LANDING, THAT IS: • FLAPS DOWN 25 UNITS OR MORE OR • GLIDE SLOPE DEVIATION IS ≤2.0 DOTS, LOCALIZER DEVIATION IS ≤2.0 DOTS AND THE FRONT COURSE LOGIC BE SATISFIED ON AN ILS APPROACH

1 FOR LANDING GEAR DOWN AND FLAPS DOWN

2 FOR GEAR UP AND/OR FLAPS UP, THE MESSAGE IS FIRST "TERRAIN TERRAIN", THEN "WHOOP WHOOP PULL UP" IF THE CONDITION CONTINUES

Figure 20 MODE 2B DESCRIPTION

MODE 2 OPERATION

Mode 2 Function

The mode 2 detector determines a presence of modes 2A and 2B and generates the required annunciations. Both, mode 2A and 2B, include a preliminary annunciation which is an alert, and after that a warning. When the airplane is in landing configuration, mode 2B has the continuous alert only.

Data Sources

The following LRUs supply these parameters.

Left, center or right radio altimeter supplies radio altitude. The GPWC computes closure rate from radio altitude.

Left inertial reference unit supplies:

- Inertial vertical speed (IVS)
- Inertial altitude
- Magnetic track.

Left or right air data computer supplies:

- Baro altitude rate
- Baro altitude
- Computed airspeed.

IVS and inertial altitude are the primary parameters. If they are not available, the mode detector uses baro altitude rate and baro altitude.

The left ILS supplies glide slope deviation, localizer deviation and selected runway heading.

The landing gear lever switch supplies landing gear lever position.

The left and center flap control units supply flap position.

GPWS warning module supplies:

- Simulated gear lever down position
- Simulated flaps down position.

The left FMC supplies magnetic track.

Alert Output

The aural -2 discrete closes switch S1 and turns on the GND PROX-G/S INHIBIT light/switch. It goes to the speech prom which generates the aural ”TERRAIN”.

The discrete from switch S1 goes to TCAS to inhibit TCAS advisories.

Warning Out-out

The aural -1:

- Goes to the speech prom which generates the aural ”WHOOP, WHOOP PULL UP”
- Closes switch S2 which causes the MAWEA to turn on both master warning lights and inhibits TCAS advisories
- Goes to the EIUs to show the red warning PULL UP on the PFDs.

Aural Output

The speech prom generates the aurals. The audio amplifier amplifies them and transmits them to the MAWEA via an output transformer. The MAWEA sends them for transmission over the captain’s and the first officer’s aural warning speakers.

Mode variations

The envelope modulation circuit supplies mode boundary variations in specific locations.

The BITE circuit supplies mode inhibit commands when circuit or input failures are present.

An output from the AIR/GROUND logic circuit inhibits all mode annunciations on the ground.

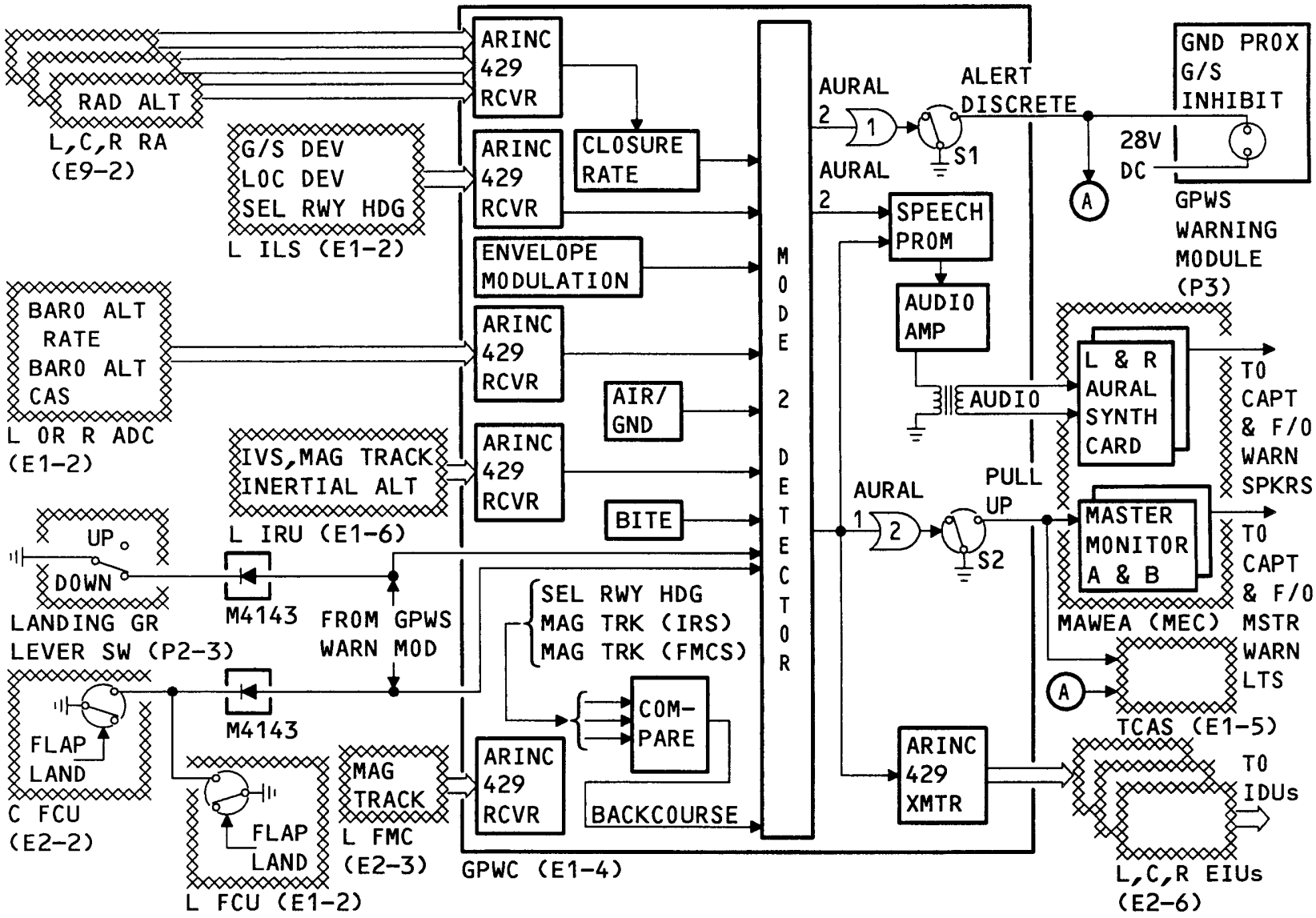


Figure 21 MODE 2 OPERATION

MODE 3 DESCRIPTION

Mode 3 Definition

Mode 3 applies to takeoff or missed approach when not in landing configuration, that is when the gear is up and/or the flaps are not 25 or 30. Mode 3 has two variations: 3A and 3B. Mode 3A starts an alert when the airplane has lost a greater amount of altitude than a threshold value. Mode 3B starts an alert when the airplane is closer to the ground than a threshold value.

Mode 3A Threshold

The mode 3A threshold depends on radio altitude and elapsed time after take off. It is roughly 10% of RA for high climb rates and 20% for low climb rates.

Mode 3A Annunciations

Mode 3A is an alert-only mode. Its annunciations are:

- The repeated aural DON'T SINK
- The illumination of the GND PROX-G/S INHB light/switch

The annunciations stop when the airplane stops losing altitude.

Mode 3B Threshold

The mode 3B threshold depends on climb rate and elapsed time since takeoff. It is 150 ft at takeoff and increases with time to about 75% of altitude gain.

Mode 3B Annunciations

Mode 3B, also is an alert-only mode. Its annunciations are:

- The repeated aural TOO LOW TERRAIN
- The illumination of the GND PROX-G/S INHB light/switch.

The annunciations stop when the airplane climbs above the mode 3B threshold value.

In a case of conflict, mode 3B annunciation takes precedence over the mode 3A annunciation.

Mode 3 To Mode 4 Transition

Modes 3 and 4 are mutually exclusive. When mode 3 is armed, mode 4 is inhibited, and vice-versa.

The switchover from mode 3 to mode 4 occurs when the mode 3B threshold reaches the value of the mode 4A threshold.

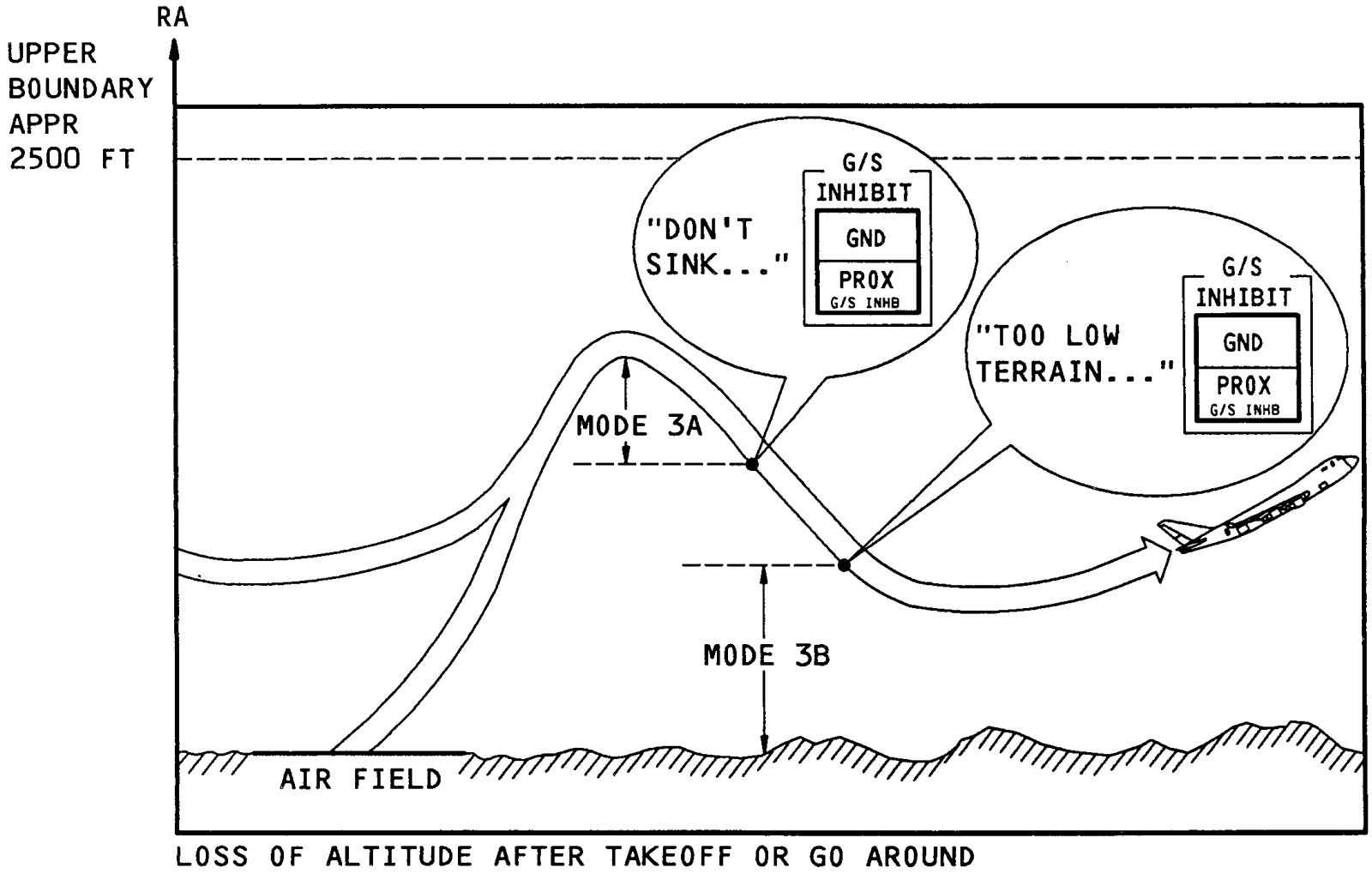


Figure 22 MODE 3 DESCRIPTION

MODE 3 OPERATION

Mode 3 Function

The mode 3 detector determines a presence of mode 3 and generates the required annunciations.

Mode 3 is an alert-only mode.

Data Sources

The following LRUs supply these parameters for the computation of mode 3 annunciations.

The left, center or right radio altimeter supplies radio altitude.

Left inertial reference unit supplies:

- Inertial vertical speed (IVS)
- Inertial altitude.

Left or right air data computer supplies:

- Baro altitude rate
- Baro altitude.

IVS and inertial altitude are the primary parameters. If they are not

available, the mode detector uses to baro altitude rate and baro altitude.

The landing gear lever switch supplies landing gear lever position.

The left and center flap control units supply flap position.

GPWS warning module supplies:

- - Simulated gear lever down position -Simulated flaps down position.

Mode Outputs

Both the aural -8 and -3 outputs:

- Close switch S1 which turns on the GND PROX-G/S INHB light/switch and inhibits TCAS advisories
- Go to the speech prom to generate the aural -8, ”DON’T SINK”, and aural -3, ”TOO LOW TERRAIN”.

Aural Outputs

The speech prom generates the aurals. The audio amplifier amplifies them and transmits them to the MAWEA via an output transformer. The MAWEA sends them for transmission over the captain’s and first officer’s aural warning speakers.

Mode Inhibit

The BITE circuit supplies mode inhibit commands when circuit or input failures are present.

Mode 3 to Mode 4 Switchover

The switchover occurs during take-off when the mode 3B threshold reaches the value of the mode 4A threshold. Mode 3 detector arms mode 4 and disables mode 3.

Mode 4 to Mode 3 Switchover

The switchover occurs during landing. When the airplane descends through the lowairspeed mode 4B boundary (at 245

ft) with gear and flaps down, mode 4 detector arms mode 3 and disables mode 4.

If at the low-airspeed mode 4B boundary (at 245 ft) the gear and/or the flaps are up, the mode 4 to mode 3 switchover occurs when the airplane descends through 30 ft RA.

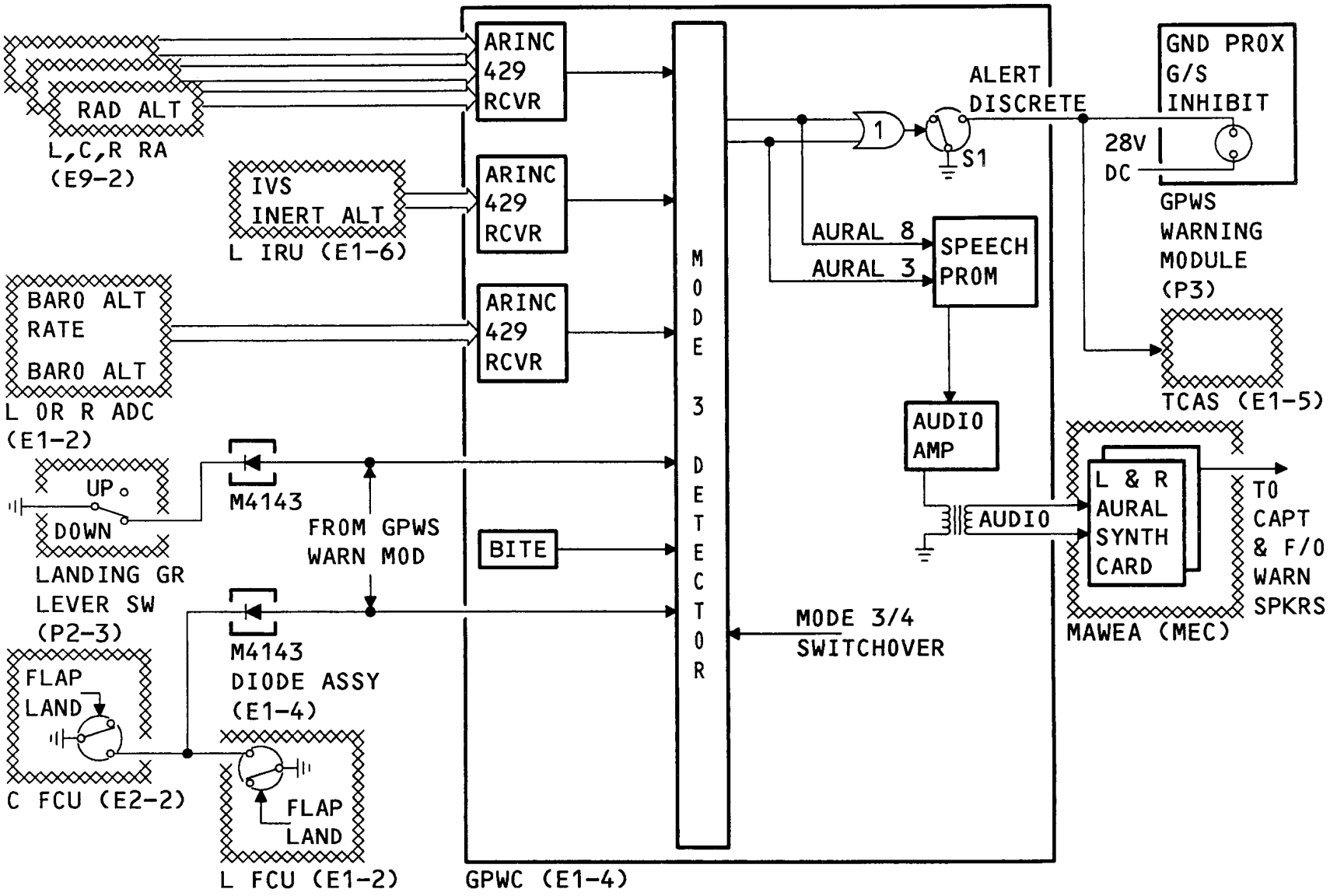


Figure 23 MODE 3 OPERATION

MODE 4 DESCRIPTION

Mode 4 Definition

Mode 4 supplies alerts when the airplane is too close to terrain and not in landing configuration. (Landing configuration is: gear and flaps down, that is flaps at 25 or 30).

Mode 4 has two variations: Mode 4A and mode 41B. mode 4A applies when the landing gear is up. Mode 4B applies when the landing gear is down.

Mode 4 Annunciations

Each one, mode 4A and mode 4B, has two variations of annunciations, which depend on computed airspeed (CAS).

At low airspeeds the annunciations are:

- For mode 4A: TOO LOW GEAR
- For mode 4B: TOO LOW FLAPS.

At high airspeeds, the annunciation is TOO LOW TERRAIN for both modes 4A and 4B.

The visual annunciation in all cases is the illumination of the GND PROX-G/S INHB light/switch.

Mode 4 Thresholds

The threshold of the low-airspeed annunciation TOO LOW GEAR in mode 4A is 500 ft RA for airspeeds up to 190 knots.

The threshold of the low-airspeed annunciation TOO LOW FLAPS in mode 4B is 245 ft RA for airspeeds up to 159 knots.

For higher airspeeds, the threshold increases to 1000 ft at 250 knots. Above 250 knots, the threshold value stays at 1000 ft. The upper boundry is revised to 800 feet for 60 seconds following a detection of exccessive rate. This helps prevent false warnings when over flying other aircraft. The lower boundary of annunciations is 30 ft.

When the flaps are down, the mode 4A threshold is 500 ft RA at all airspeeds.

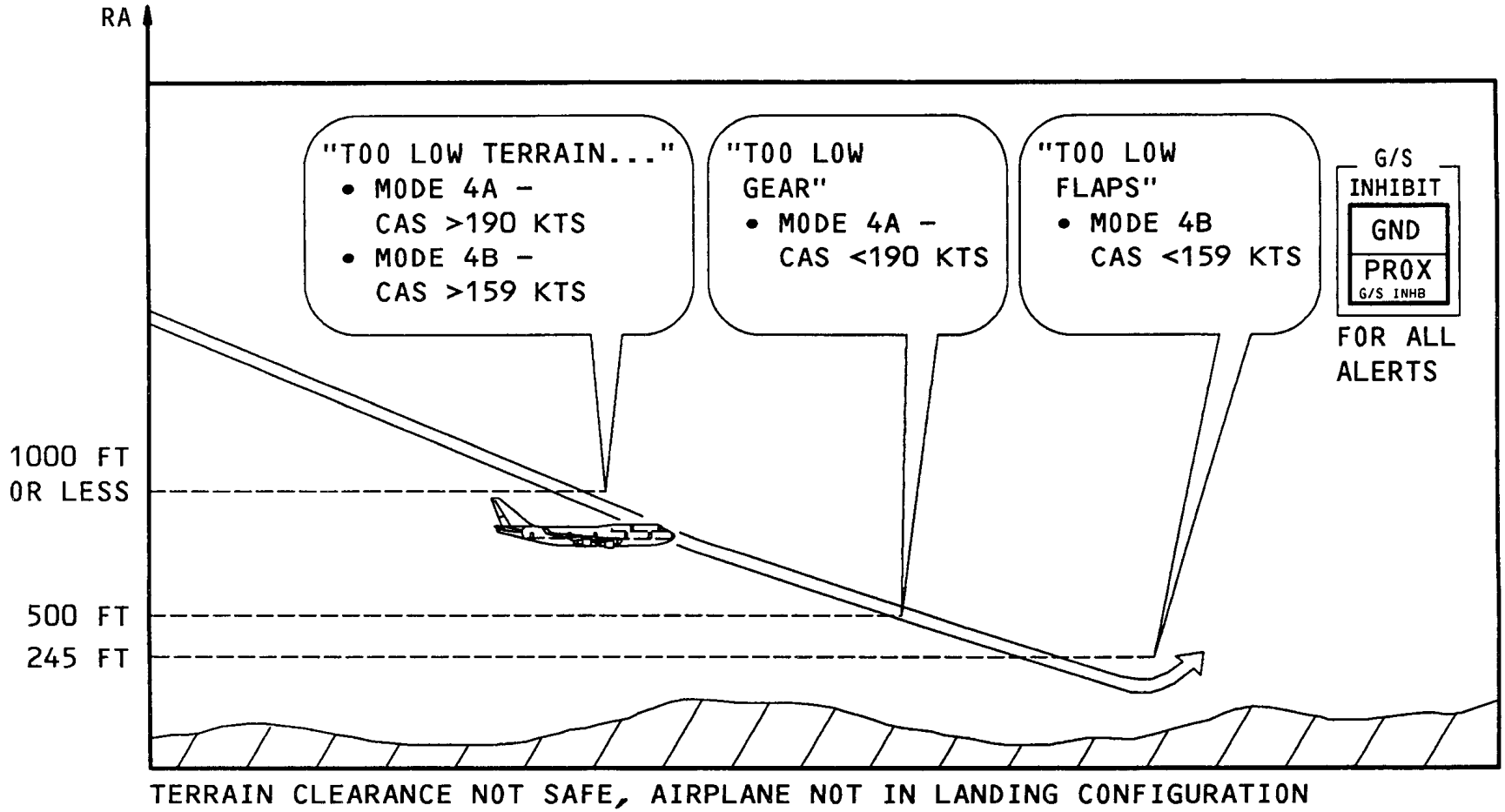


Figure 24 MODE 4 DESCRIPTION

MODE 4 OPERATION

Mode 4 Function

The mode 4 detector determines a presence of mode 4A or 4B and generates the required annunciations.

The modes 4A and 4B are alert-only modes.

Data Sources

The following LRUs supply these parameters for the computations of modes 4A and 4B:

- L, C or R RA supplies radio altitude
- Left or right ADC supplies computed airspeed (CAS)
- Landing gear lever switch supplies landing gear up or down position
- C or L FCU supplies flap position
- GPWS warning module supplies simulated gear down and/or or flap down.

Mode 4 Outputs

The mode 4 detector turns on the GND PROXG/S INHB light/switch when switch S1 closes. One of three aural output discretes, aurals-3, -4, and -5 generate in the speech prom the aurals:

- Aural 3: ”TOO LOW TERRAIN”
- Aural 4: ”TOO LOW GEAR”
- Aural 5: ”TOO LOW FLAPS”.

When switch S1 closes, a discrete goes to TCAS to inhibit TCAS advisories.

Aurals

The speech prom generates the aurals. An audio amplifier amplifies them and transmits them to the MAWEA via an output transformer. The MAWEA sends the aural to the captain’s and first officer’s aural warning speakers.

Mode 4 Variations

The envelope modulation circuit supplies mode boundary variations in specific geographic locations.

The BITE circuit supplies mode inhibit commands when circuit or input failures are present.

An output from the AIR/GND logic circuit inhibits all mode annunciations on the ground.

Mode 4 to Mode 3 Switchover

A mode 4 to mode 3 switchover occurs during landings. When the airplane descends through the low-airspeed mode 4B boundary (at 245 ft) with the gear and flaps down, the mode 4 detector arms mode 3 and disables mode 4.

If at the low-airspeed mode 4B boundary (at 245 ft) the gear and/or flaps are up, the mode 4 to mode 3 switchover occurs when the airplane descends through 30 ft radio altitude.

Mode 3 to Mode 4 Switchover

The mode 3 to mode 4 switchover occurs during take-off. The mode 3 detector arms mode 4 and disables mode 3 when the mode 3B threshold reaches the value of the mode 4A threshold.

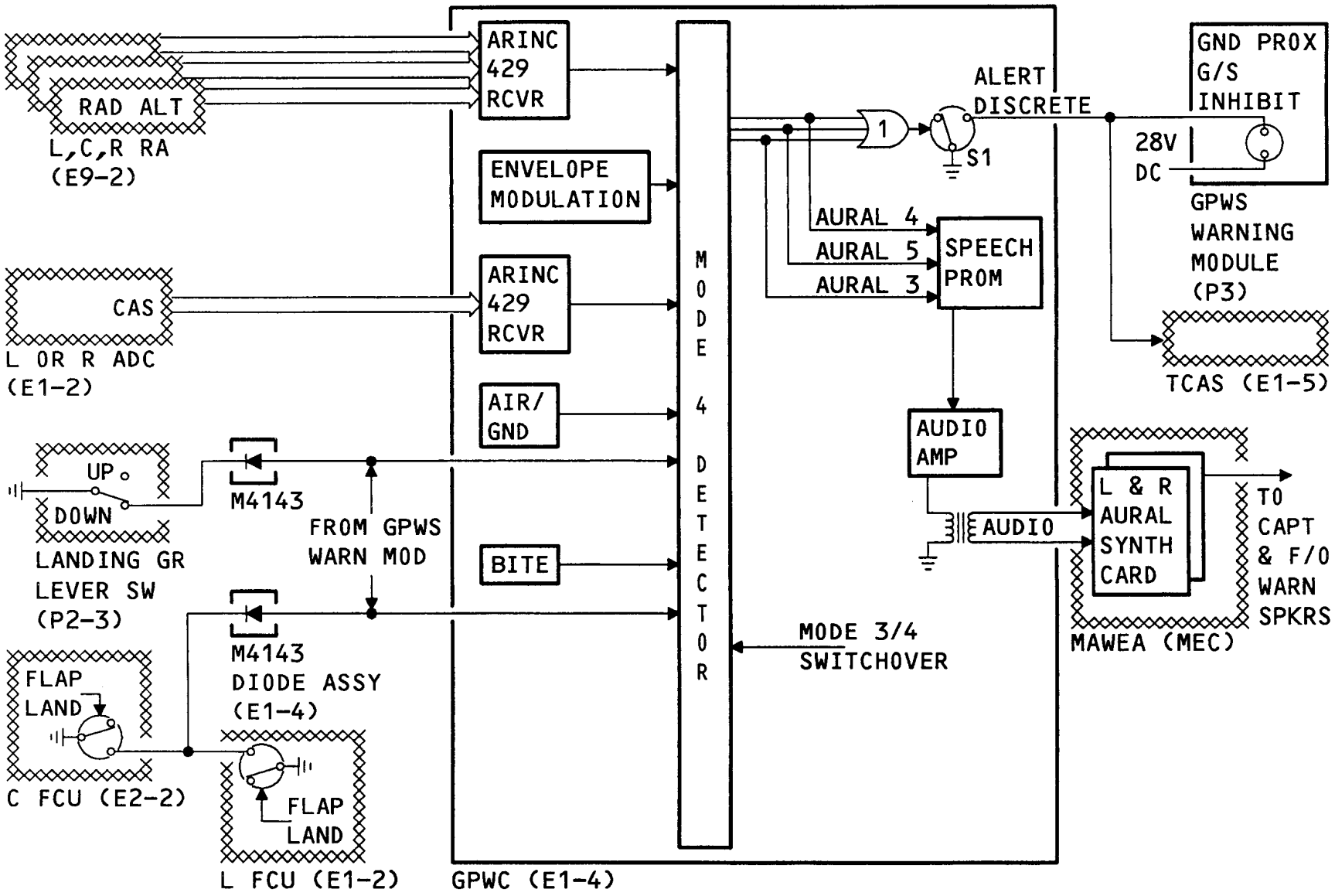


Figure 25 MODE 4 OPERATION

MODE 5 DESCRIPTION

Mode 5 Definition and Annunciations

The mode 5 envelope limits are determined by monitoring radio altitude and deviation below the glide slope.

mode 5 indications can occur between 1000 feet down to 30 feet RA.

Mode 5 is armed when the airplane descends below 1000 feet RA, the landing gear is down and the localizer is captured (within 2 dots) before descending below 500 ft.

Mode 5 is an alert-only mode. mode 5 annunciations are:

- The repeated aural ”GLIDE SLOPE” at different repetition rates and sound levels, and
- The illumination of the GND PROX-G/S INHB light/switch.

Aural Repetition Rate

The repetition rate of the glide slope aural is increased as the terrain clearance decreases and/or the glide slope deviation increases.

Aural Sound Levels

Mode 5 has two sound levels:

- Below 1000 ft RA with a glide slope deviation greater than 1.3 dots (below glide slope), the aural ”GLIDE SLOPE” is at half volume.
- Below 300 ft RA with a glide slope deviation greater than 2 dots (below glide slope), the aural ”GLIDE SLOPE” is at normal level.

Mode 5 Inhibit or Cancellation

The GND PROX-G/S INHB light/switch inhibits or cancels mode 5 below 1000 ft RA nominal. If mode 5 is not in operation, a push on the switch inhibits any future mode 5 annunciations. If mode 5 is in operation, a push on the switch cancels any visual and aural annunciations. It is not possible to rearm mode 5 by another push on the switch. To rearm mode 5, the airplane must either descend below 30 ft RA or ascend above 1000 ft RA.

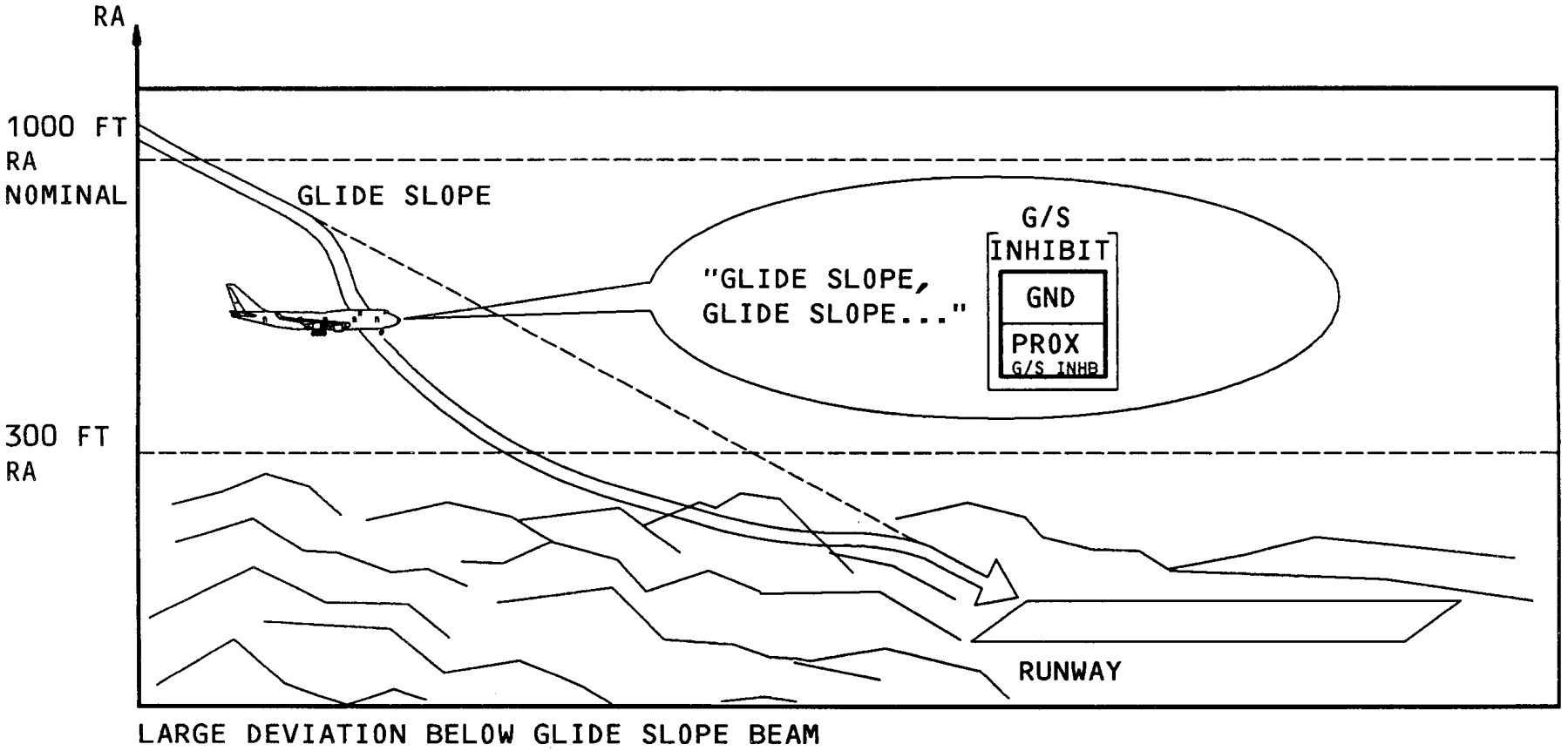


Figure 26 MODE 5 DESCRIPTION

MODE 5 OPERATION

Mode 5 Function

The mode 5 detector determines the presence of mode 5 and generates the required annunciations.

Data Sources

Mode 5 inputs are:

- Radio altitude from the left, center or right radio altimeter
- Glide slope and localizer deviation and selected runway heading from the left ILS receiver
- Magnetic track from the left FMC (primary source)
- Magnetic track from the left IRU (alternate source)
- Landing gear lever switch position
- Glide slope inhibit discrete from the GPWS warning module
- Simulated gear lever down position from the configuration gear override switch

Heading Compare

The backcourse compare circuit inhibits mode 5 annunciations during back-course. The airplane is in backcourse when the angle between selected runway heading and magnetic track is greater than 90 degrees.

Mode Outputs

The aural 9 output:

- Closes switch S1 turns on the GND PROXG/S INHB light/switch, and inhibits TCAS advisories
- Goes to the speech prom to generate the GLIDE SLOPE aural

Aural Output

The speech prom generates the aural. The audio amplifier amplifies it and sends to the MAWEA via the output transformer. The MAWEA sends the aural to the captain’s and first officer’s aural warning speakers.

Repetition Rate

Based on radio altitude and glide slope deviation, the GIS voice repetition rate circuit adjusts the repetition rate of the aural annunciation.

Sound Levels

The mode 5 detector reduces the amplifier gain to half volume when the air-plane:

- Glide slope deviation is less than two dots, and/or
- RA is not below 300 feet

Mode 5 Inhibit or Cancellation

The GND PROX-G/S INHB light/switch inhibits or cancels mode 5 below 1000 feet radio altitude.

Mode Variations

The envelope modulation circuit supplies mode boundary variations in specific locations.

The BITE circuit supplies mode inhibit commands when circuit or input failures are present.

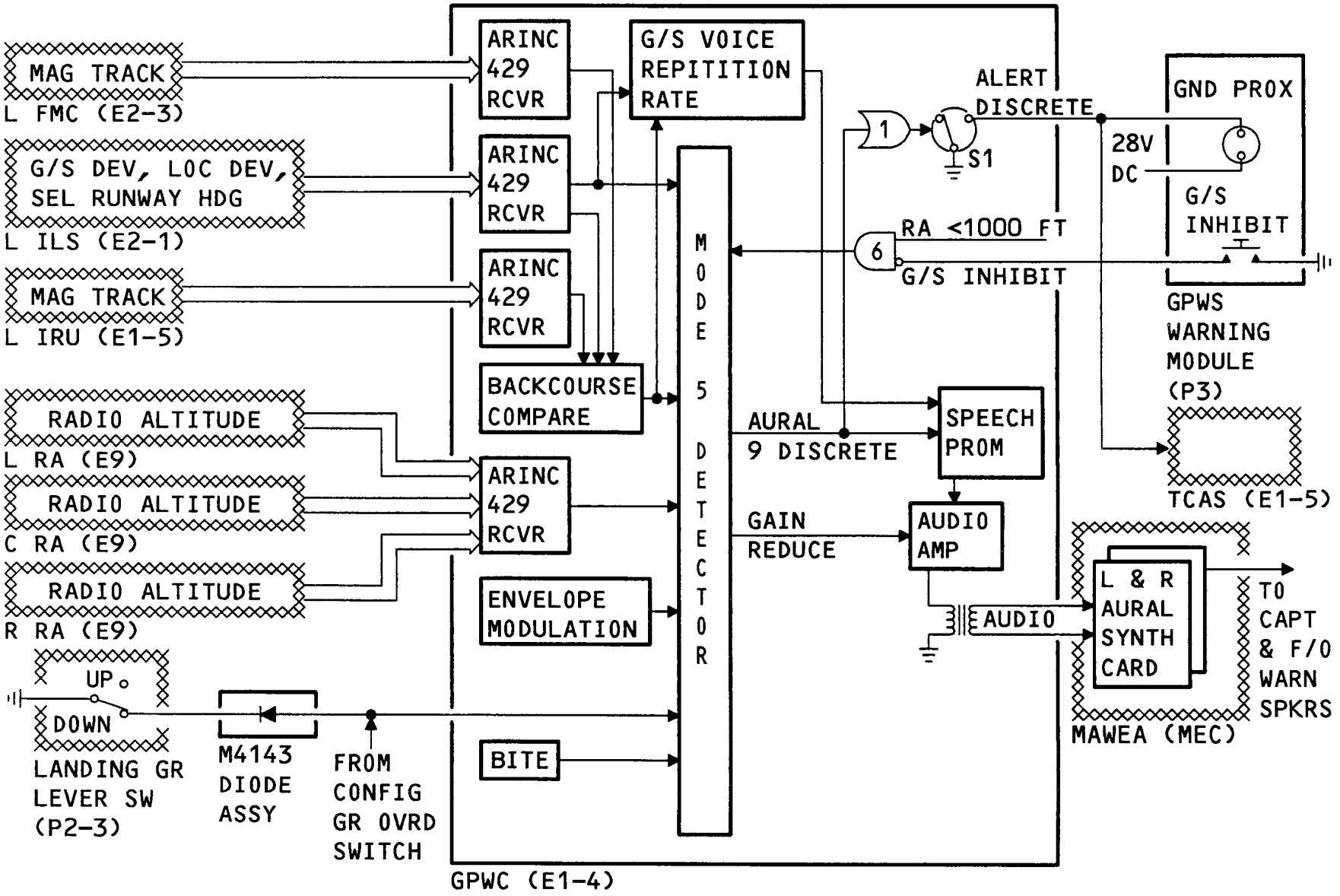


Figure 27 MODE 5 OPERATION

MODE 6 DESCRIPTION

Mode 6 Definition

An optional GPWC feature is mode 6 aural callouts. This mode does not give visual displays. one or more pin selections determine the RA callout configuration.

RA Callout Selection

The present radio altitude aural callout configuration selected produces the aural messages shown when the airplane descends through these pre-determined radio altitudes:

- ONE HUNDRED at 100 feet
- FIFTY at 50 feet
- THIRTY at 30 feet

BANK ANGLE BANK ANGLE sounds when the roll angle exceeds 40 degrees at all altitudes above 150 feet. The alert sounds when the roll angle increases by 20 percent.

Mode 6 Reset

Mode 6 callouts sound only once. To repeat the callouts sequence, the airplane must ascend above 1000 feet radio altitude.

Volume

The volume of the callouts is one quarter of the level of the other modes.

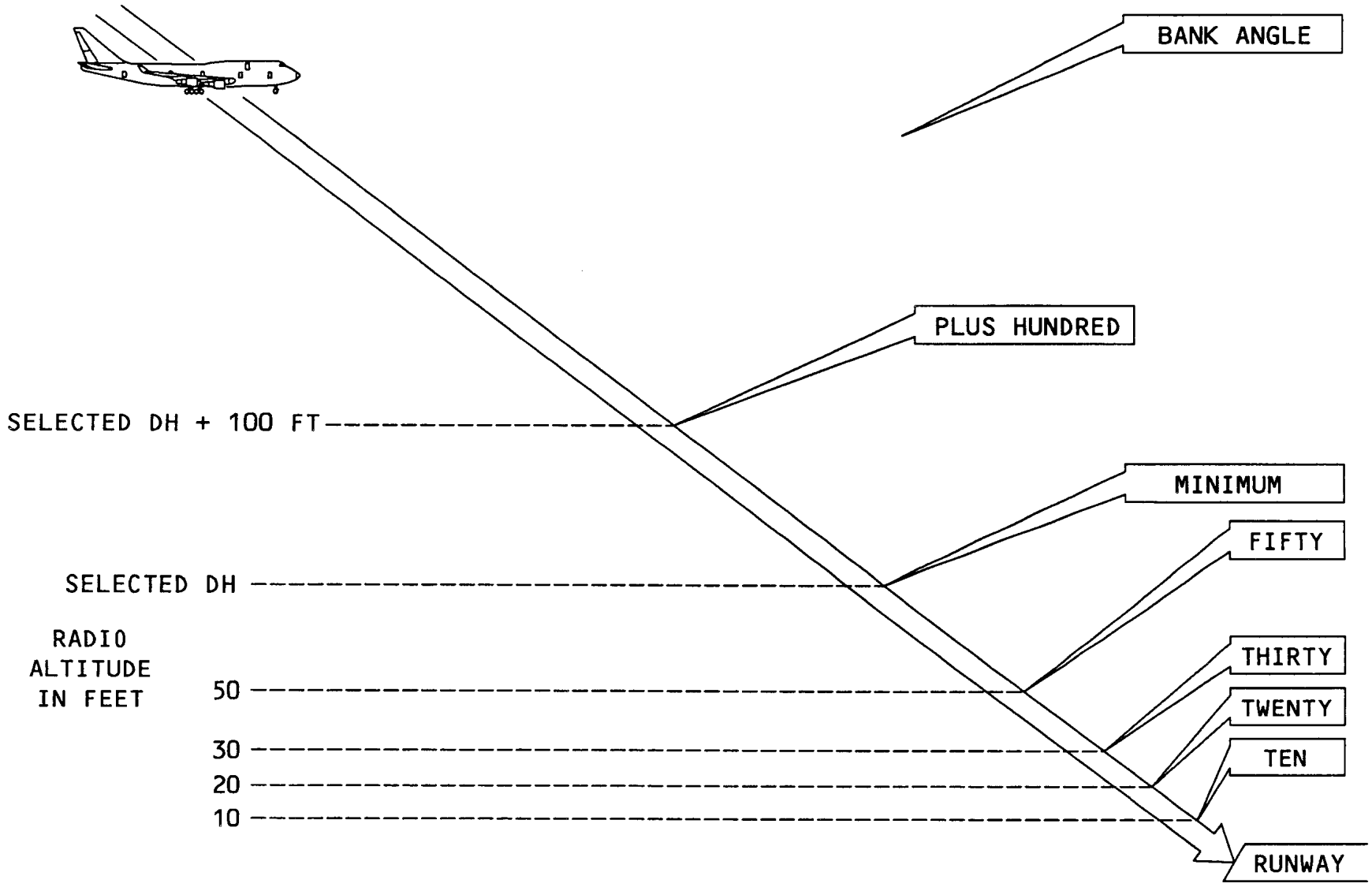


Figure 28 MODE 6 DESCRIPTION

MODE 6 OPERATION

Mode 6 Function

The mode 6 detector generates the selected radio altitude callouts at predetermined radio altitudes.

Data Sources

Mode 6 inputs are:

- Radio altitude from the left, center or right RA
- Roll angle from the left IRU
- Landing gear lever position
- Simulated gear lever down position from the configuration gear override switch.

Program Pins

The program pin RA CALLOUT ENABLE enables the mode 6 function.

Various program pins define the RA callout configuration.

The RA CALLOUT LO VOLUME program pin reduces the volume of the callout to onequarter of normal level.

Mode Outputs

The radio altitude callout aural discretes go to the speech prom to generate the aurals.

The audio amplifier amplifies them to one quarter normal volume (LO VOLUME) and sends them to the MAWEA via the output transformer. The MAWEA sends them to the captain's and first officer's aural warning speakers.

Mode six does not include the illumination of the GND PROX-G/S INHB light/switch.

Mode 6 Reset

Each of the mode 6 annunciations can sound only once. To reset the mode 6 function, the airplane must climb above 1000 feet.

Above 150 feet the alert "BANK ANGLE BANK ANGLE" sounds at 40 degrees of roll angle measured by the left IRU. The alert sounds at 10 degrees of roll angle at 30 feet. The alert set point increases to 40 degrees at 150 feet.

The alert repeats for each 20 percent increase in roll angle.

Mode Variations

The envelope modulation circuit removes the gear down requirement in specific locations.

The BITE circuit supplies inhibit commands when circuit or input failures are present.

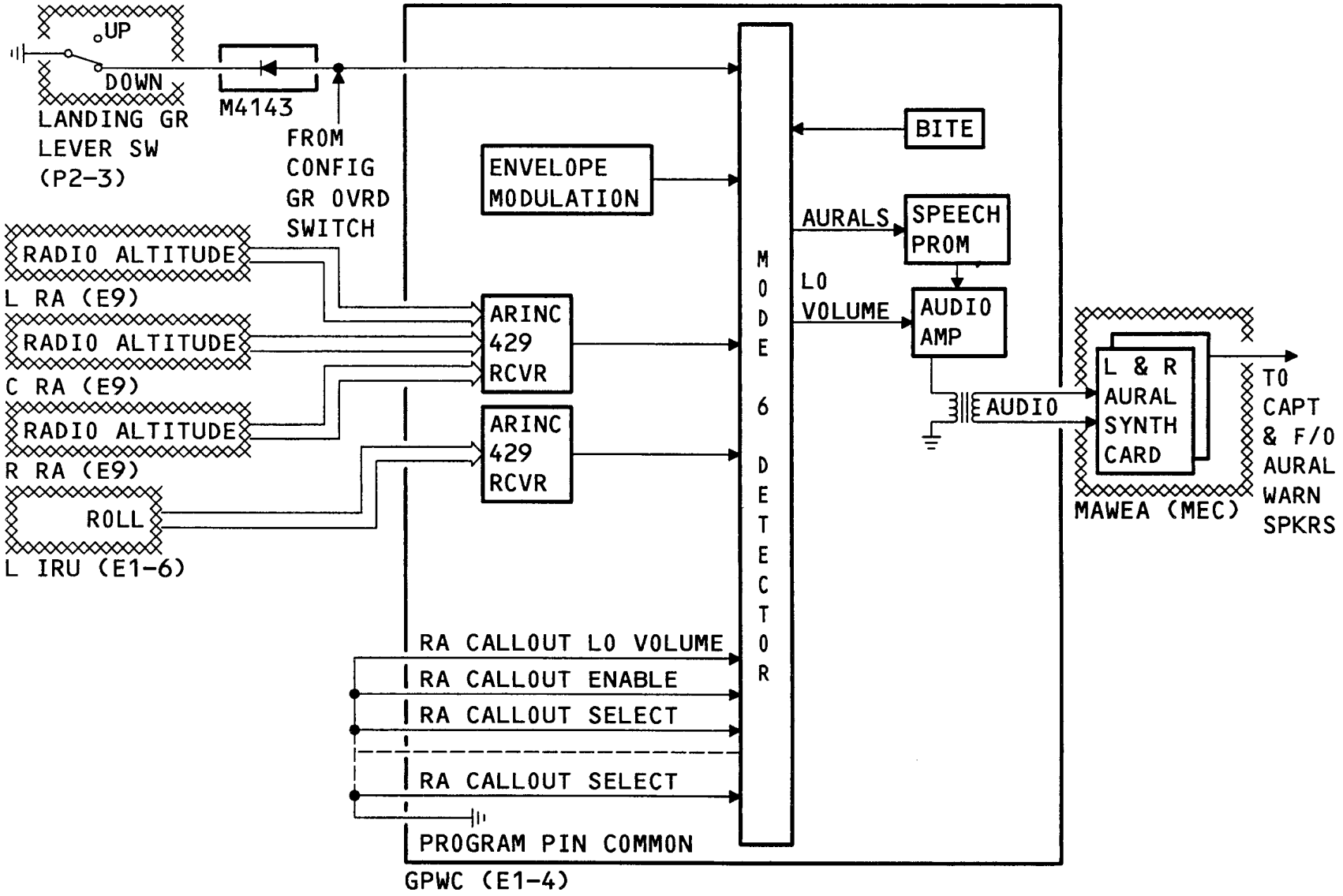


Figure 29 MODE 6 OPERATION

MODE 7 DESCRIPTION

Reactive Windshear Detection

An optional GPWC feature is mode 7 reactive windshear detection. Windshear can happen anywhere in the atmosphere. It can have both horizontal and vertical components, and consists of large volumes of air which move quickly in different (usually opposite) directions.

One type of windshear which is most dangerous to airplanes is the microburst, which has a column of downward-moving air. Microbursts are most dangerous below 500feet, where pilots have little time and airspace to recover. The graphic shows a microburst situation on approach.

Warnings

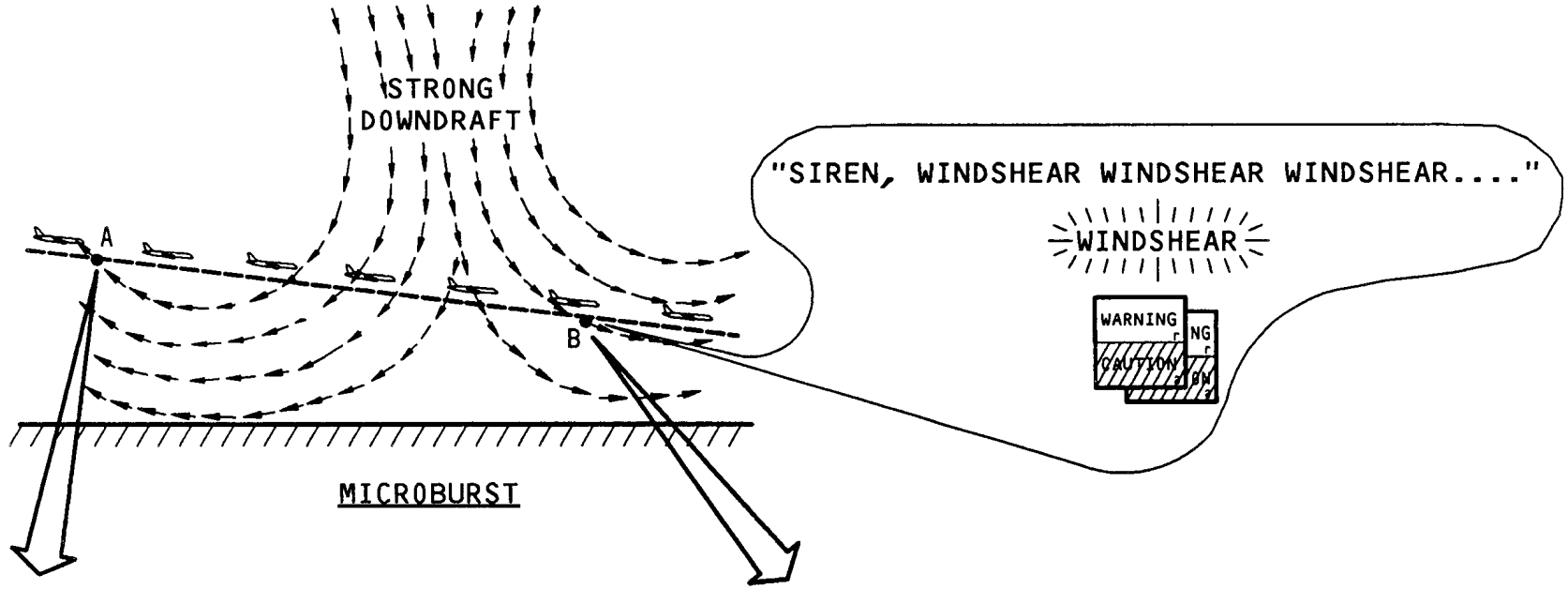
Mode 7 produces a warning for a windshear condition during takeoff or final approach, below 1500 feet radio altitude.

A windshear warning includes these annunciations;

- A siren sounds followed by the repeated aural message ”windshear, windshear, windshear,
- A red WINDSHEAR warning message shows on the PFDs.
- The master warning lights come on.

The windshear warning annunciations continue as long as the windshear condition exists and the indicated AOA is within four degrees of stick shaker AOA, but no less than five seconds.

The GPWC inhibits all other GPWS modes during a windshear warning.



POSITION A

- HEADWIND
- UPDRAFT

POSITION B

- TAILWIND
- DOWNDRAFT
- WINDSHEAR EFFECT:
  - REDUCTION IN AIRSPEED
  - REDUCTION IN LIFT

POSITION B ANNUNCIATION: WARNING

- AURAL: SIREN, THEN "WINDSHEAR...."
- RED MESSAGE "WINDSHEAR" ON PFD'S
- MASTER WARNING LIGHTS

Figure 30 MODE 7 DESCRIPTION

MODE 7 OPERATION

Mode 7 Function

The mode 7 detector computes a vertical and a horizontal windshear component, that combine to yield a total windshear indication, in takeoff or in approach. The detector compares this windshear indication to thresholds which are a function of approach/takeoff flap position. If the windshear indication exceeds the threshold, the mode 7 detector issues a warning.

Data Sources

The following LRUs supply these parameters for the computation of the windshear indication.

Left, center or right radio altimeter (L, C or R RA) supplies radio altitude.

Left inertial reference unit (L IRU) supplies:

- Inertial vertical speed
- Pitch angle
- Pitch rate
- Roll angle
- Longitudinal acceleration
- Normal acceleration
- Vertical acceleration
- Attitude mode.

Left and right stall warning cards in the MAWEA supply:

- Indicated angle of attack (AOA)
- Corrected angle of attack
- Stick shaker angle of attack
- Flap angle
- Minimum operating speed.

The left stall warning card is the primary source. If it fails, the mode detector uses data from the right stall warning card.

The right ADC and the left or center ADC supplies:

- True airspeed (TAS)
- Computed airspeed (CAS).

Center flap control unit (C FCU) or left FCU supplies flap position of 25 units or greater.

Program Pins

Program pins enable the mode 7 function and select the airplane type (747-400).

Mode Out-outs

The aural-10 discrete issues the windshear warnings. It:

- Causes the speech prom to generate the repeated aural-10 WINDSHEAR...
- Closes switch S3 which inhibits WAS advisories and causes the MAWEA to turn on both master warning lights
- Causes the EIUs to show the red message WINDSHEAR on the PFDs.

Aural Out-outs

The speech prom generates the aural WINDSHEAR. The audio amplifier amplifies it and transmits it to the MAWEA via an output transformer. The MAWEA sends the aural for transmission over the captain’s and first officer’s aural warning speakers.

Mode Inhibit

The BITE circuit issues mode inhibit commands when circuit or input failures are present.

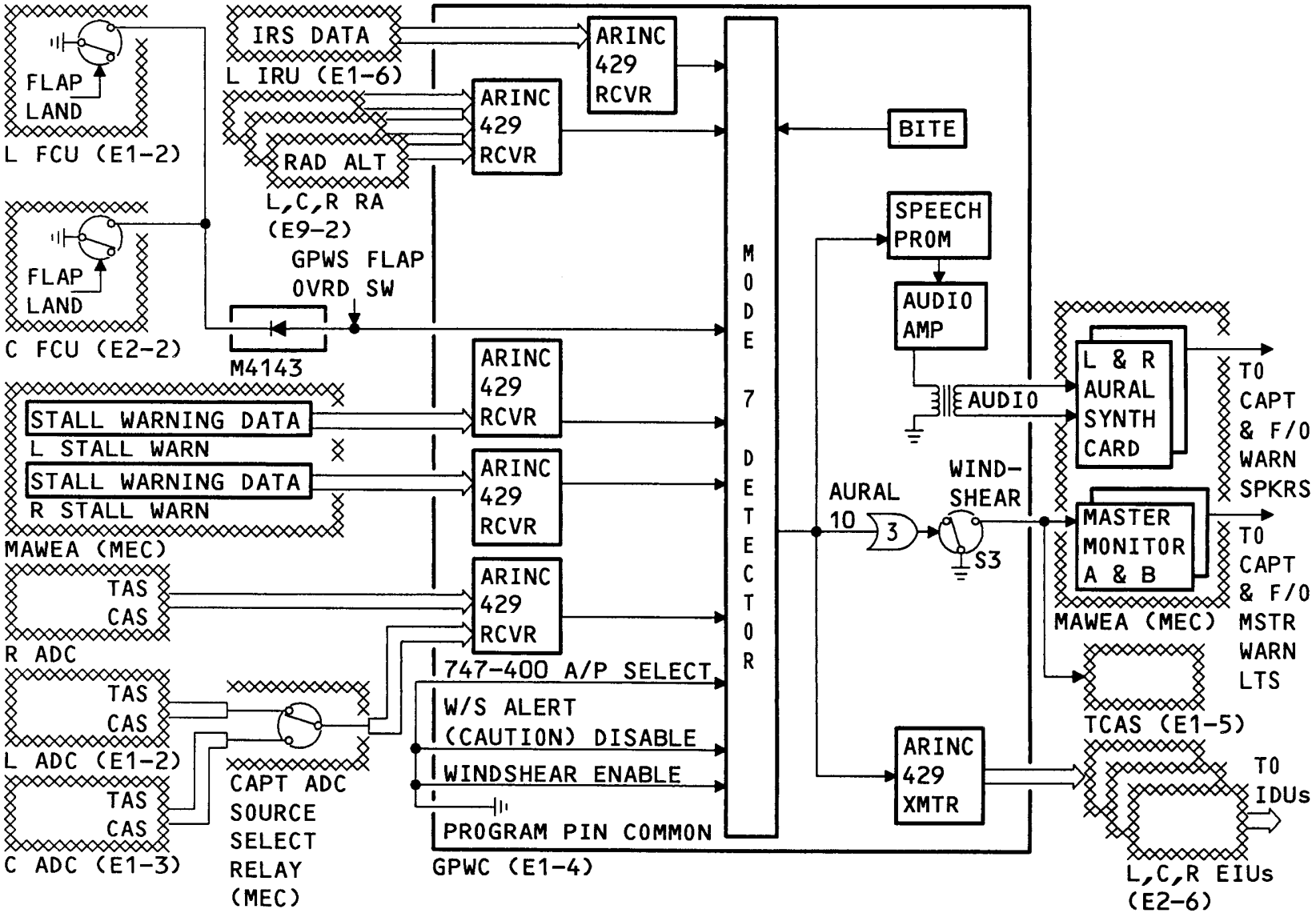


Figure 31 MODE 7 OPERATION

TERRAIN AWARENESS FUNCTION

Purpose

The ground proximity warning computer (GPWC) compares the airplane flight profile, flap and gear position, and terrain clearance to determine if an alert or warning condition exists.

Terrain Awareness Inputs

The GPWC receives airplane data from the air data computers (ADC), inertial reference system (IRS) and the global positioning system (GPS). The terrain awareness function uses this data:

- Latitude
- Longitude
- Barometric altitude
- Ground track
- Ground speed
- Heading
- Roll attitude
- Flight path angle (calculated by GPWC).

Terrain awareness uses GPS for latitude and longitude. It uses IRS data if the GPS data is invalid or not available.

Terrain Awareness Calculation

The GPWC stores a world-wide terrain database in memory. The GPWC looks at airplane position and track, and compares this data to the terrain database. If the GPWC determines there is a terrain threat, it makes an alert.

Terrain Display Output

The GPWC makes a digital map of the terrain forward of the airplane. It sends this digital map to the navigational displays (NDs). The display uses different colored dots to show terrain altitude relative to airplane altitude.

Terrain Alert Outputs

If the GPWC determines the airplane is about 60 seconds from a terrain conflict, it makes a terrain caution alert. The caution alert is as follows:

- Alert aural message CAUTION TERRAIN
- Amber message TERRAIN shows on the ND
- The terrain display shows on both NDs if not selected on either one
- The threat terrain on the ND changes from dots to a solid yellow color
- The ground proximity warning light comes on.

If the GPWC determines the airplane is about 30 seconds from a terrain conflict, it makes a terrain warning alert. The warning alert is as follows:

- Aural message TERRAIN, TERRAIN PULL UP
- A red PULL UP message shows on the primary flight display (PFD)
- A red TERRAIN message shows on the ND
- The terrain display shows on both NDs if not selected on either one
- The terrain threat on the ND changes from dots to a solid red color
- The master warning lights come on.

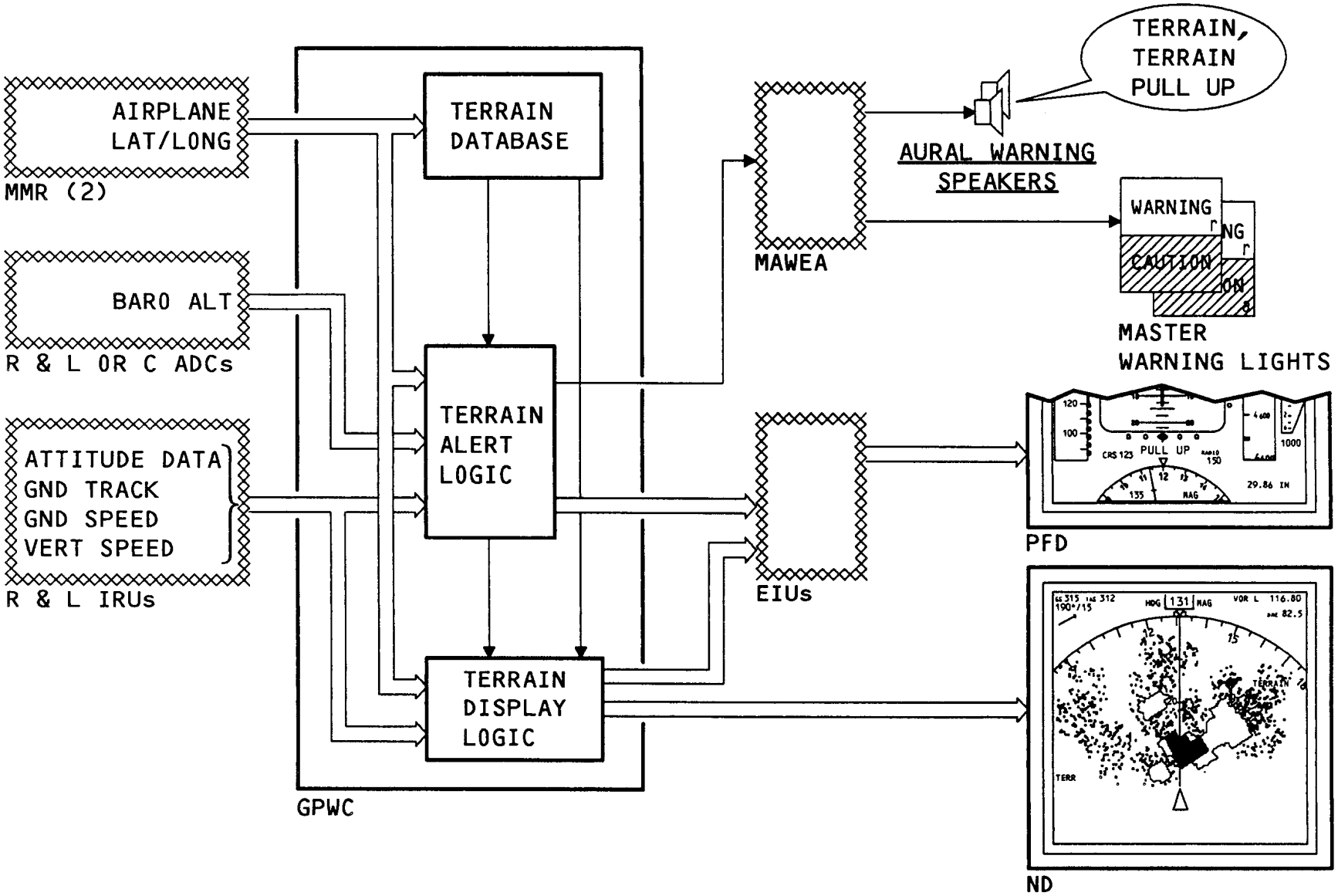


Figure 32 TERRAIN AWARENESS FUNCTION

TERRAIN CLEARANCE FLOOR

Description

Terrain clearance floor (TCF) alerts the flight crew when the airplane descends too low on approach. TCF uses airplane position and a runway database to determine if an alert condition exists.

Terrain Clearance Floor Inputs

The ground proximity warning system (GPWS) receives airplane data from these systems:

- Global positioning system (GPS)
- Air data computers (ADCs)
- Inertial reference system (IRS)
- Radio altimeters (RA).

TCF uses this data:

- Latitude
- Longitude
- Radio altitude.

TCF uses GPS for latitude and longitude. It uses IRS data if GPS data is not valid.

Terrain Clearance Floor Logic

The GPWC stores a runway database in memory. This database contains the location of all hard surface runways in the world that are 3,500 feet or more in length. TCF makes a terrain clearance envelope around the runway. The altitude of the envelope increases as the distance from the airport increases. GPWC compares airplane latitude, longitude, and radio altitude with TCF envelope data. If the airplane descends through the floor of the envelope, GPWC makes an alert.

TCF makes an alert even if the airplane is in landing configuration.

Terrain Clearance Floor Caution Alert

If the GPWC determines the airplane is below the TCF, it makes this caution alert:

- Aural message TOO LOW TERRAIN. This message repeats for each 20 percent loss of altitude.
- The ground proximity warning light comes on and stays on until the airplane climbs above the TCF.

There is no TCF warning alert.

The GPWC inhibits TCF alerts for any of these conditions:

- Airplane is on the ground
- Less than 20 seconds after takeoff
- Less than 30 feet radio altitude.

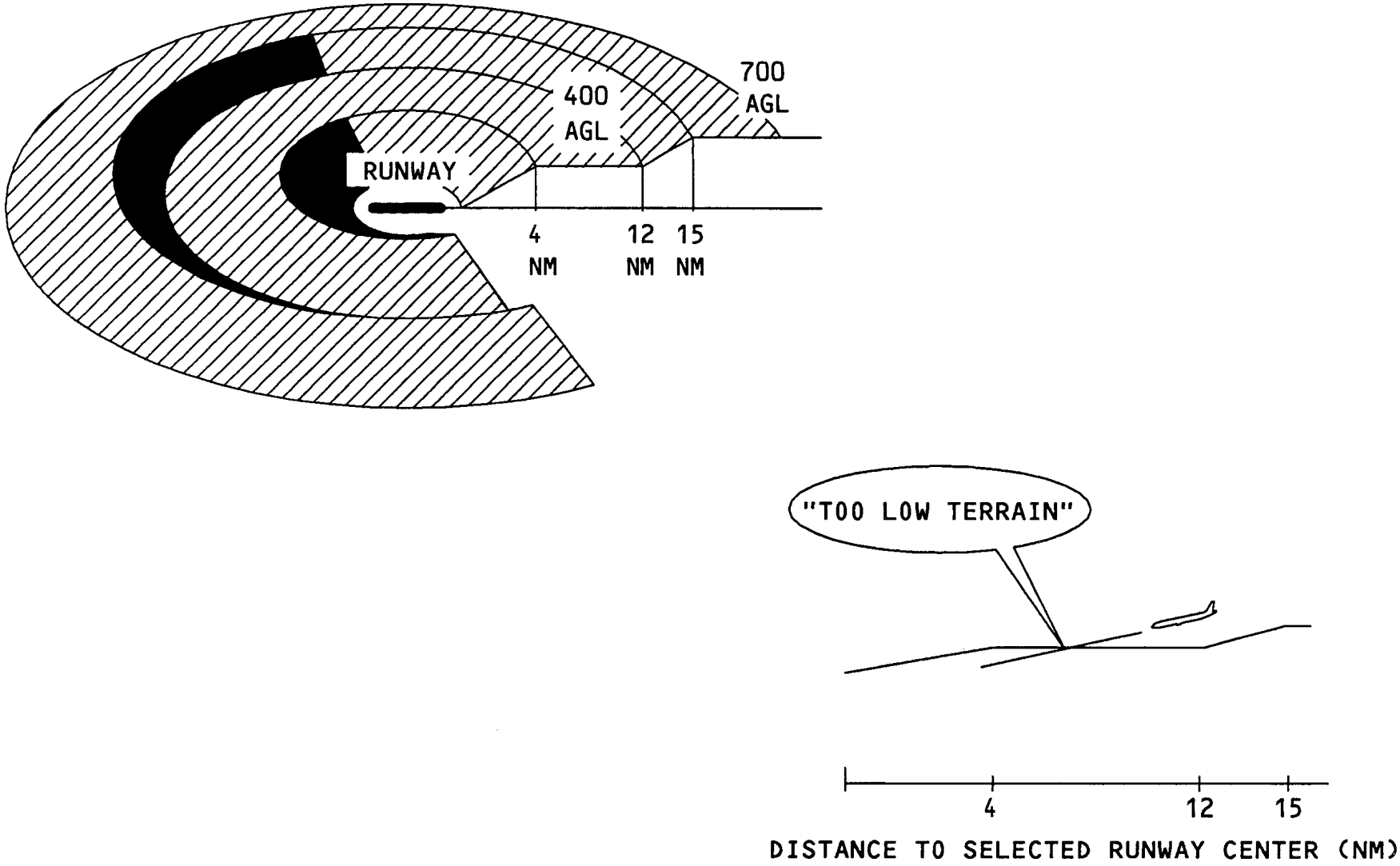


Figure 33 TERRAIN CLEARANCE FLOOR

ENVELOPE MODULATION DESCRIPTION

Purpose

Envelope modulation modifies specific alert and warning thresholds in localities with marginal ground proximity terrain conditions.

Envelope modulation:

- Prevents mode 1, 2, and 4 nuisance annunciations.
- Allows mode 5 annunciations at higher altitudes with the gear not down.
- Allows mode 6 annunciations with the gear not down.

This function applies to over 100 locations around the world.

Method

Envelope modulation takes place only in specifically defined locations and conditions. The GPWC uses latitude and longitude to determine the location of the airplane. The GPWC then uses parameters such as radio altitude, magnetic track, glide slope deviation,

runway heading, baro corrected altitude and/or localizer deviation to determine that the airplane is in exactly defined conditions that call for the modulation of the thresholds. The parameters that must have specified values are called the KEY. When the KEY is correct, the GPWC modifies the respective mode thresholds.

Mode Modulations

The present graphic lists the modes that can be modulated and the purpose. In the case of modes 1, 2, and 4, modulation reduces the margin of safety and thus prevents nuisance annunciations. In mode 5, envelope modulation raises the radio altitude thresholds and removes the geardown requirement which enable annunciations at higher altitudes. In mode 6, the modulation removes the gear-down requirement.

MODE	TYPE OF MODULATION	PURPOSE OF MODULATION
1	RAISE DESCENT RATE THRESHOLD	ALLOW GREATER BAROMETRIC DESCENT RATES WITHOUT NUISANCE ALERTS/WARNINGS
2	LOWER RADIO ALTITUDE THRESHOLD	ALLOW FLIGHT CLOSER TO TERRAIN WITHOUT NUISANCE ALERTS/WARNINGS
4	LOWER RADIO ALTITUDE THRESHOLD	LOWER MINIMUM TERRAIN CLEARANCE AT HIGHER AIRSPEEDS AND PREVENT NUISANCE ALERTS
5	• RAISE RADIO ALTITUDE THRESHOLD • REMOVE GEAR-DOWN REQUIREMENT	ALLOW MODE 5 ANNUNCIATIONS AT HIGHER ALTITUDES WITHOUT GEAR DOWN
6	• REMOVE GEAR-DOWN REQUIREMENT	ALLOW MODE 6 ANNUNCIATIONS WITHOUT GEAR DOWN

Figure 34 ENVELOPE MODULATION DESCRIPTION

ENVELOPE MODULATION OPERATION

Envelope Modulation Function

The envelope modulation module contains a look-up table that lists all the locations by latitude/longitude that require envelope modulation. The airplane's latitude and longitude is continuously monitored. When the airplane enters an area that requires modulation, the module checks to see if the airplane parameters correspond to the modulation KEY in the look-up table. If the parameters match, modulation proceeds at a predetermined schedule.

Position Data

The left GPS is the primary source of latitude, and longitude. If the left GPS is not available, the modulation module defaults to the right GPS, then to the left FMC.

Other Data Sources

In addition to the data from the GPS receivers and the left FMC, these parameters are required for the determination of the modulation KEY:

- Glide slope deviation, localizer deviation, and selected runway heading from the left ILS receiver
- Radio altitude from the left, center or right RA
- Barometric corrected altitude from the right ADC, and the left or center ADC
- Magnetic track from the left FMC, or the left or right IRU.

Mode Detector Modulation

When the modulation module determines the modulation requirements, signals are sent to the respective mode detectors. The mode detectors modify the threshold values and/or remove the gear-down requirement for the various ground proximity modes that are present.

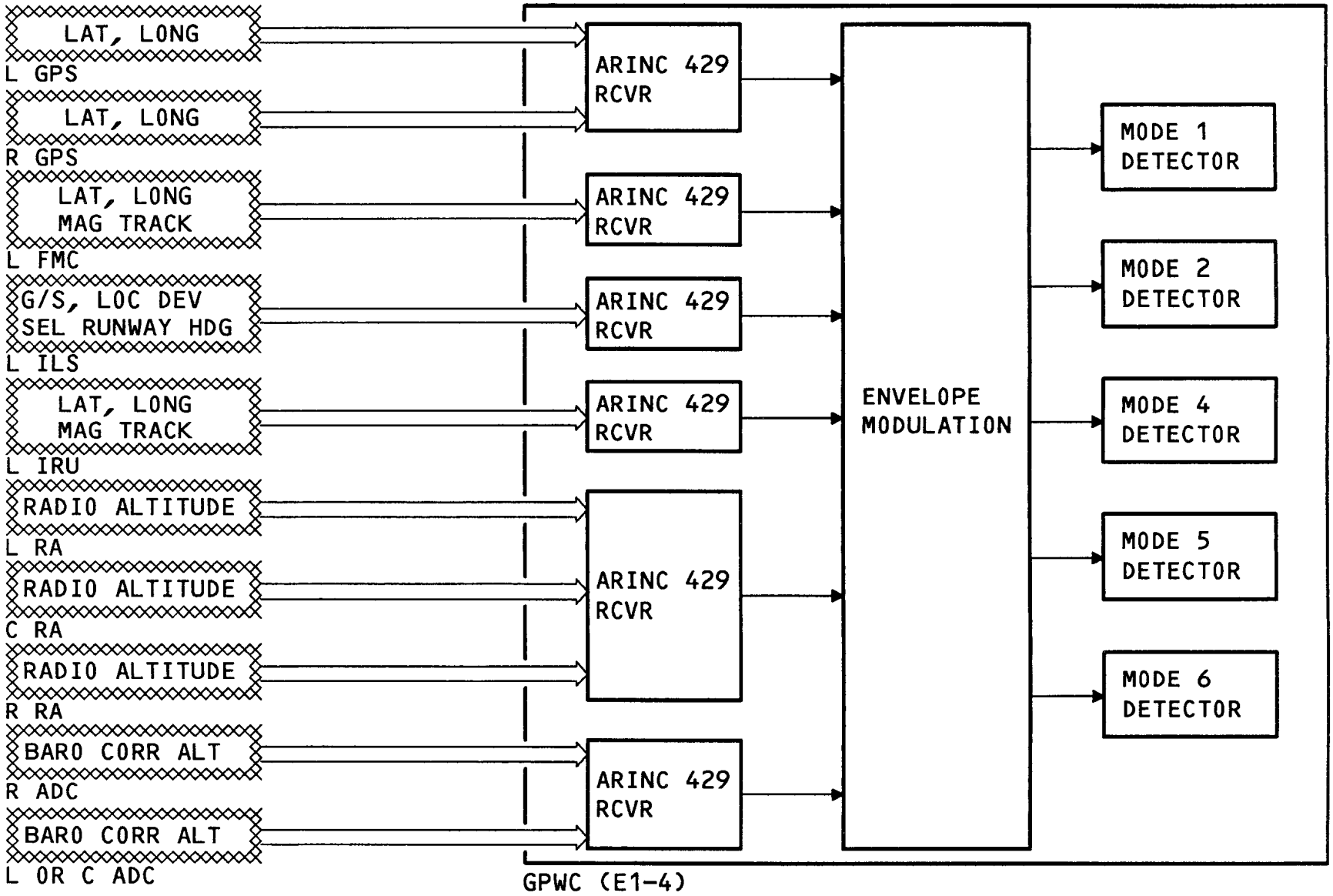


Figure 35 ENVELOPE MODULATION OPERATION

GPWS - MODE SUMMARY

General

This summary shows this information:

- GPWS modes
- Mode conditions
- Aural messages for each mode
- Lights or displays that come on.

MODES	CONDITION			AURAL MESSAGE	PFD-RED MESSAGE	ND MESSAGE	GND PROX-G/S INHIBIT LIGHT	MWL
1	INITIAL ANNUNCIATION			"SINK RATE..."			X	
	WARNING			"WHOOP WHOOP PULL UP..."	PULL UP			X
2A	FLAPS ≤20 AND G/S DEV >2 DOTS	INITIAL ANNUNCIATION		"TERRAIN TERRAIN"			X	
		WARNING		"WHOOP WHOOP PULL UP..."	PULL UP			X
		ALTITUDE GAIN FUNCTION: • STARTS WHEN MODE 2 CONDITION STOPS • ENDS WHEN 300 FT OF INERTIAL ALT IS GAINED OR GEAR GOES DOWN		"TERRAIN.."			X	
2B	FLAPS ≥25 OR G/S DEV <2 DOTS	FLAPS AND GEAR DOWN		"TERRAIN.."			X	
		FLAPS AND/OR GEAR UP	INITIAL ANNUNCIATION	"TERRAIN TERRAIN.."			X	
			WARNING	"WHOOP WHOOP PULL UP.."	PULL UP			X
3A	FLAPS ≤20 AND/OR GEAR UP (FOR ALTITUDE LOSS OF APPROXIMATELY 10% TO 20%)			"DON'T SINK..."			X	
3B	FLAPS ≤20 AND/OR GEAR UP. RA LESS THAN THRESHOLD VALUE.			"TOO LOW TERRAIN.."			X	
4A	GEAR UP	AIRSPEED <190 KNOTS AND RA <500 FT		"TOO LOW GEAR.."			X	
		AIRSPEED >190 KNOTS AND RA CHANGES BUT EQUAL TO OR LESS THAN 1000 FT		"TOO LOW TERRAIN.."			X	
4B	GEAR DOWN FLAPS ≤20	AIRSPEED <159 KNOTS AND RA <245 FT		"TOO LOW FLAPS.."			X	
		AIRSPEED >159 KNOTS AND RA CHANGES BUT EQUAL TO OR LESS THAN 1000 FT		"TOO LOW TERRAIN.."			X	
5	ILS FRONT COURSE APPROACH AND GEAR DOWN	RA <1000 FT AND G/S DEVIATION >1.3 DOTS		"GLIDE SLOPE..." AT 1/2 VOLUME, FREQ PROPORTIONAL TO DEVIATION AND GROUND PROXIMITY.			X	
		RA <300 FT AND G/S DEVIATION >2.0 DOTS		"GLIDE SLOPE..." AT FULL VOLUME, FREQ PROPORTIONAL TO G/S DEVIATION AND GROUND PROXIMITY.			X	
6	GEAR DOWN			RADIO ALTITUDE CALLOUTS AS SELECTED BY PROGRAM PINS				
7	WINDSHEAR CONDITION			SIREN, THEN "WINDSHEAR, WINDSHEAR, WINDSHEAR..."	WINDSHEAR			X
TERR	APPROX. 60 SEC. TO THREAT TERRAIN			"CAUTION, TERRAIN.."		TERRAIN	X	
	APPROX. 30 SEC. TO THREAT TERRAIN			"TERRAIN, TERRAIN, PULL UP.."	PULL UP	TERRAIN		X
TCF	AIRPLANE BELOW TERRAIN CLEARANCE FLOOR			"TOO LOW TERRAIN.."			X	

Figure 36 MODE SUMMARY

POWER AND ANALOG INPUTS

Power

A dedicated GPWS circuit breaker sends 115 volts ac to the GPWC. In the GPWC it passes through an electromagnetic interference (EMI) filter and goes to the internal power supply.

Flap and Landing Gear Position

Discretes that show flap and landing gear positions either arm or inhibit certain modes.

These are the input sources for the flap discrete:

- The center flap control unit
- The left flap control unit
- The ground proximity flap override switch.

These are the input sources for the landing gear discrete:

- The landing gear lever switch
- The ground proximity configuration/ gear override switch.

To simulate flaps-down and gear-down positions, push the override switches on the GPWS warning module. They simulate a flaps-down (25 units or greater) and a landing-gear-down condition, respectively.

Air/Ground Logic

The input from the air/ground relays plus computed air speed and radio altitude define an IN-AIR or an ON-GROUND condition. The transition from ON-GROUND to IN-AIR occurs when the air/ground relays show IN-AIR (contacts closed) and radio altitude is five feet or more. If the relays mistakingly show ON-GROUND (contacts open), the transition occurs when the airspeed is 90 knots or more and the radio altitude is five feet or more.

The transition from IN-AIR to ON-GROUND occurs when the airspeed is 60 knots or less and the radio altitude is one foot or less.

The Air/Ground logic does this:

- Inhibits modes 2 and 4 on the ground
- Inhibits flight deck tests in the air
- Defines the start and end of a flight leg in fault memory.

28v DC Signal In-out

The positions of the Capt and FIO terrain display relays are sent to the GPWC as a 28v dc relay monitoring discrete.

Terrain Display Override

The terrain override switch on the GPWS warning module sends a discrete to the GPWC to override the terrain awareness and alerting display.

Program Pins

There are 26 program pin inputs to the GPWC. These are some of the selections for your airplane:

- TRIPLE RA SELECT; enables the GPWC to process one of three radio altimeter inputs.
- A/P type; identifies the 747-400
- WINDSHEAR ENABLE; enables the mode 7 windshear warning
- WINDSHEAR CAUTION DISABLE; disables the windshear caution function
- RA CALLOUT ENABLE; enables the radio callout configuration defined by the RA CALLOUT SELECT program pins
- MODE 6 LOW VOLUME; reduces the volume of the RA callouts to a quarter of normal level
- The CMC ENABLE program pin allows the use of the data received on the ARINC 429 CMC input bus.

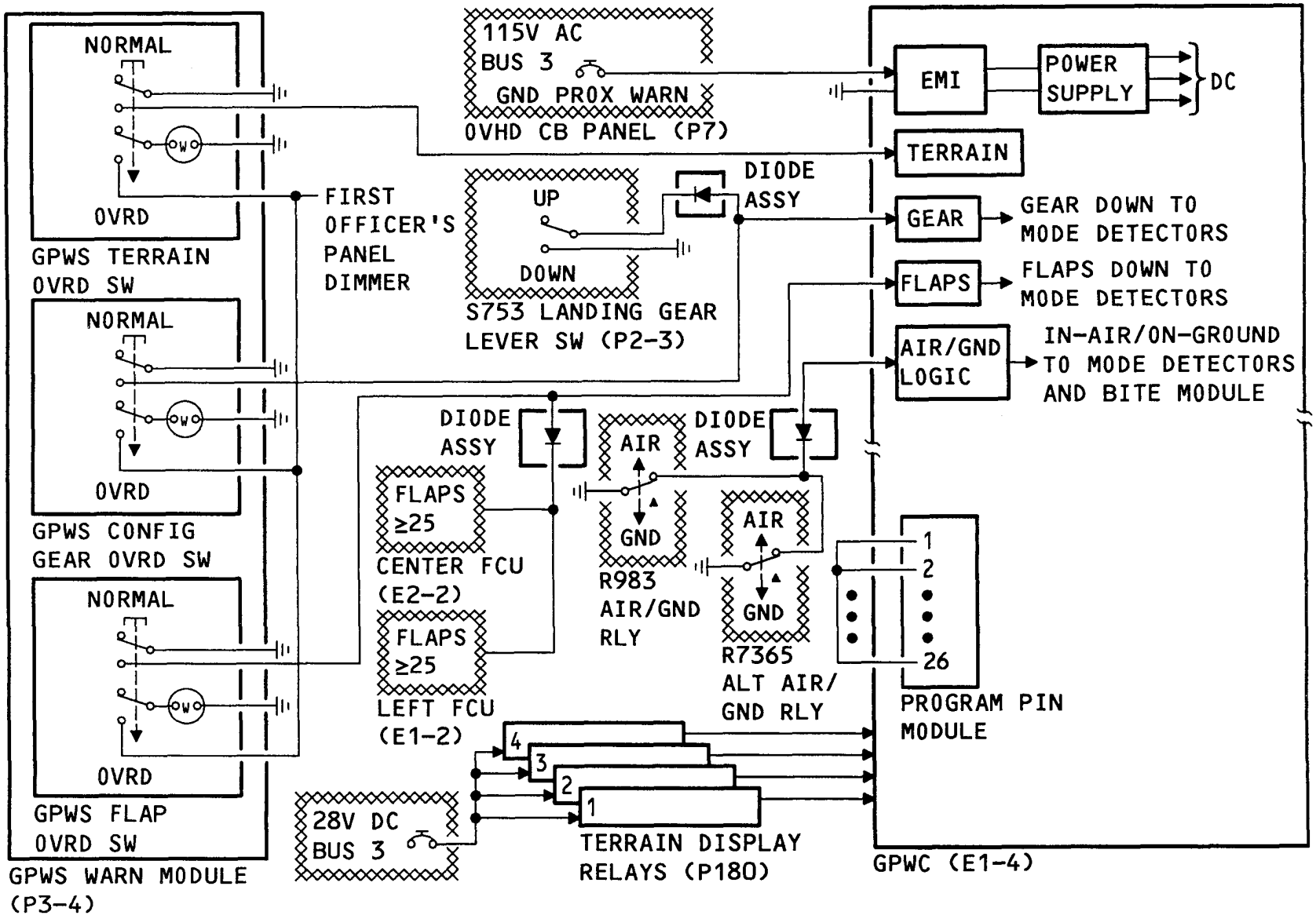


Figure 37 POWER AND ANALOG INPUTS

OVERRIDE CAPABILITIES

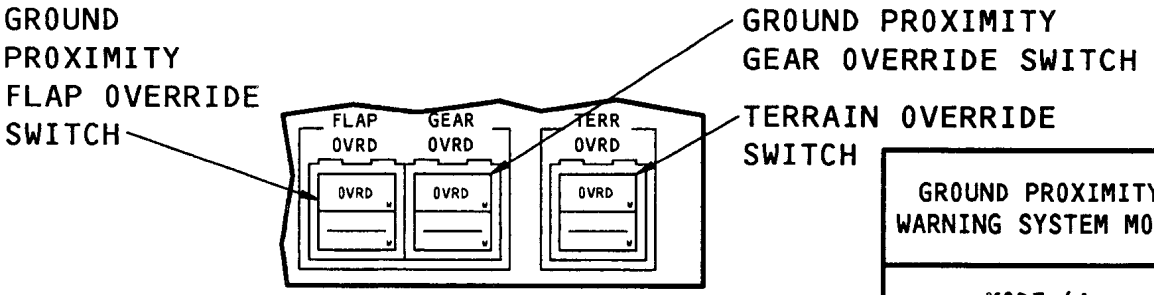
General

The ground proximity warning module override switches modify or inhibit certain modes.

These are the ground proximity warning module switches:

- Ground proximity flap override switch
- Ground proximity gear override switch
- Terrain override switch.

The graphic shows some switch override effects.



GROUND PROXIMITY WARNING SYSTEM MODE	FLAP AND GEAR POSITION	OVERRIDE SWITCH ACTIVE	EFFECT OF OVERRIDE SWITCH
MODE 2A LARGE CLOSURE RATE WHEN NOT IN LANDING (FLAPS UP AND G/S DEVIATION > 2 DOTS)	FLAPS UP. GEAR UP OR DOWN.	FLAP	MODE 2A CHANGES TO MODE 2B
		GEAR	INHIBIT ALTITUDE GAIN FUNCTION
MODE 2B LARGE CLOSURE RATE WHEN IN LANDING (FLAPS DOWN AND G/S DEVIATION < 2 DOTS)	FLAPS DOWN AND GEAR UP	GEAR	"WHOOP WHOOP PULL UP" CHANGES TO "TERRAIN". RED MWL CHANGES TO AMBER AND GND PROX LIGHT
	FLAPS UP AND GEAR DOWN	FLAP	
MODE 3A LARGE ALTITUDE LOSS IN CLIMB-OUT OR GO-AROUND WITH FLAPS AND/OR GEAR UP	FLAPS UP AND GEAR DOWN	FLAP	INHIBIT MODE 3
	FLAPS DOWN AND GEAR UP	GEAR	INHIBIT MODE 3

GROUND PROXIMITY WARNING SYSTEM MODE	FLAP AND GEAR POSITION	OVERRIDE SWITCH ACTIVE	EFFECT OF OVERRIDE SWITCH
MODE 4A TERRAIN CLEARANCE NOT SAFE WITH GEAR UP	FLAPS UP	FLAP	AT HIGH SPEED, THRESHOLD CHANGES FROM 1000' TO 500'
		GEAR	MODE 4A CHANGES TO MODE 4B
	FLAPS DOWN	GEAR	INHIBIT MODE 4
MODE 4B TERRAIN CLEARANCE NOT SAFE WITH GEAR DOWN AND FLAPS UP		FLAP	INHIBIT MODE 4
MODE 5 BELOW GLIDESLOPE WITH GEAR UP		GEAR	ENABLE MODE 5
MODE 6 RADIO ALTITUDE CALLOUTS WITH GEAR DOWN		GEAR	ENABLE MODE 6
TERRAIN TERRAIN THREAT		TERRAIN	INHIBIT TERRAIN ALERTS

NOTE: THE OVERRIDE SWITCHES HAVE NO EFFECT ON MODES 1 AND 7

Figure 38 OVERRIDE CAPABILITIES

TERRAIN SELECT RELAY INTERFACE

Purpose

The ground proximity warning computer (GPWC) and the weather radar (WXR) receiver-transmitters (RTs) send display data that shows on the navigational displays (NDs). Four terrain select relays control which data shows on each ND.

Relay Power

The terrain select relays gets 28v dc from the TERRAIN DISPLAY circuit breaker on the P7 overhead circuit breaker panel.

Relay Interfaces

The GPWC connects to all terrain select relays with ARINC 453 terrain display data buses. The WXR RTs connect to all terrain select relays with weather display data buses.

The terrain select relays connect to the NDs with data buses.

Relay Control

With weather radar selected, the normal relay position lets weather radar data show on the NDs. When you select TERR on either EFIS control panel (CP), a terrain select ground signal energizes the two onside terrain select relays. This allows the terrain data to show on the on-side display. Push the TERR switch again and the on-side relays deenergize. The display then shows weather radar data, if selected.

Relay Monitor

The GPWC monitors the terrain select relay positions for faults.

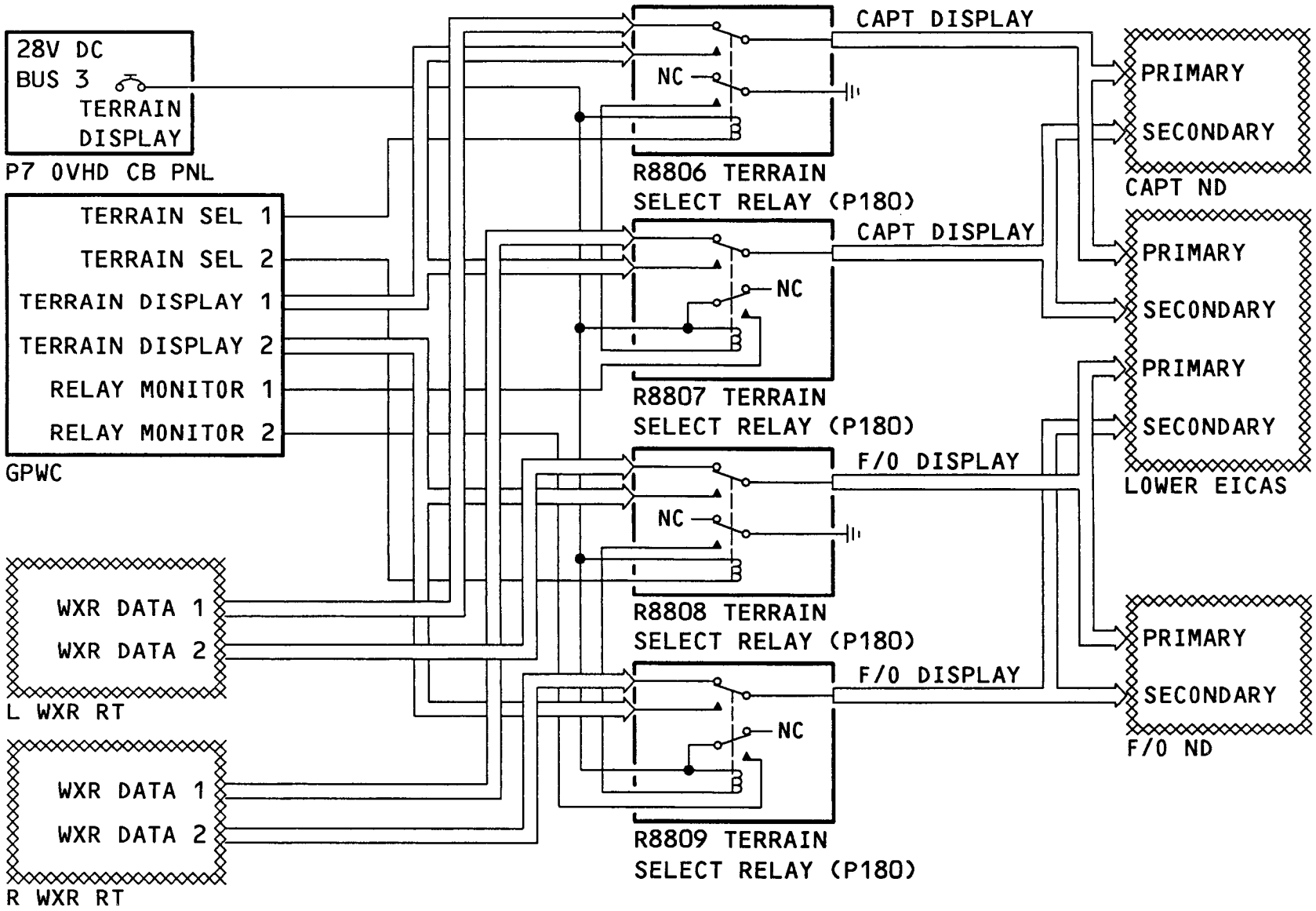


Figure 39 TERRAIN SELECT RELAY INTERFACE

EFIS CONTROL PANEL

Description

The EFIS control panel provides these functions:

- Enables the navigation displays (NDs) to show terrain data
- Supplies the selection of different ND modes
- Supplies the selection of different ranges for terrain data to show on the NDs.

TERR Map Switch

When you push the TERR map switch on the EFIS control panel, terrain data shows on the on-side ND. Push the TERR map switch again to remove the display.

ND Mode Selector

Use the ND mode selector to select an ND mode. The ND modes that show terrain data are:

- Expanded APP (approach) mode
- Expanded VOR mode
- Expanded MAP mode
- Centered MAP mode.

If the mode selector is not in a correct mode when you push the TERR map switch, the terrain display arms. When armed, the terrain display shows as soon as you change the ND selector to a correct mode. The terrain display stays armed even if you push the TERR map switch again. Push the WXR map switch to disarm the terrain display and arm the weather display.

ND Range Selector

The EFIS control panel has a six position range selector. The range selections are 10, 20, 40, 80, 320 and 640 NM. The map mode displays the range at all times. APP and VOR modes display the range only when TERR or WXR data show.

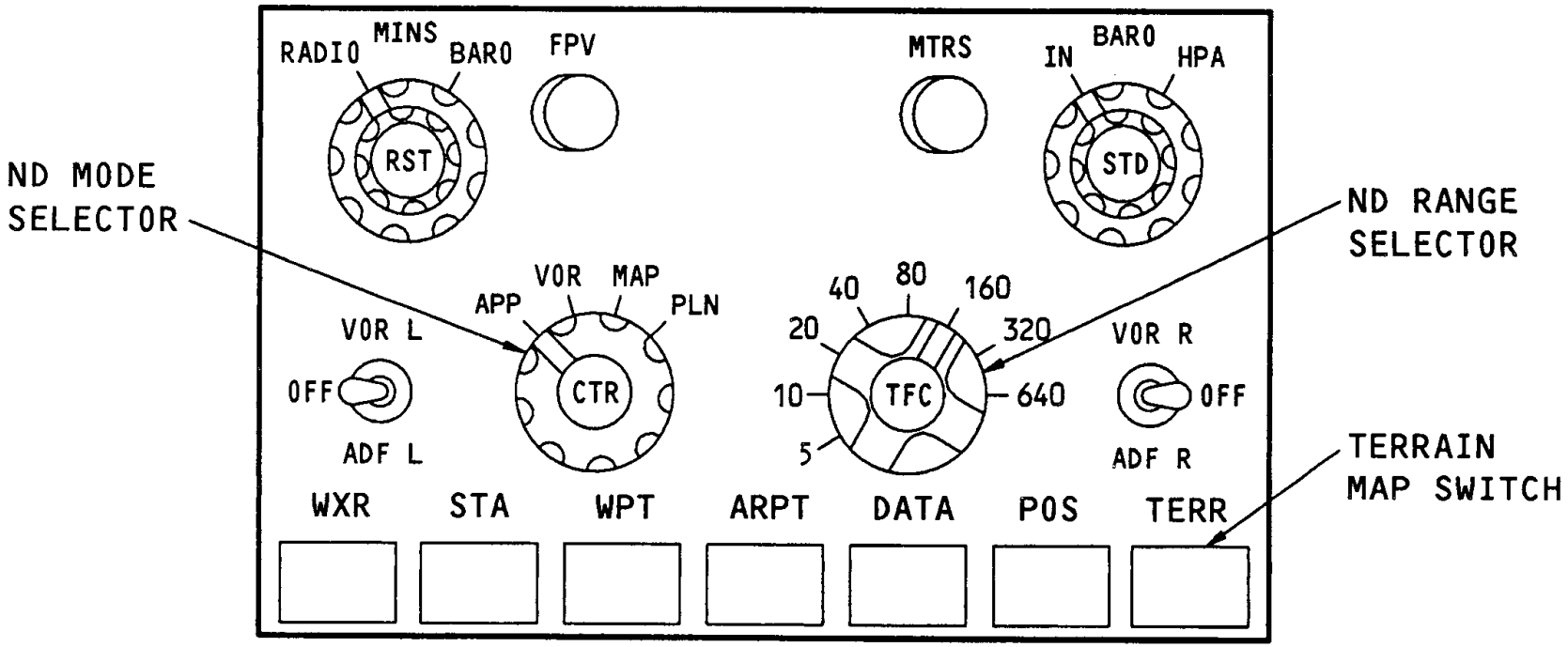


Figure 40 EFIS CONTROL PANEL

SPEECH PROM

Purpose

The speech prom gets discretes from mode detectors, generates the aurals, and sends the aurals to the audio amplifier.

Order of Priority

The speech prom generates no more than one annunciation at a time. If several aural discretes arrive at the same time, the speech prom generates the one with the highest priority.

When a higher priority mode occurs while a lower priority mode is in progress, the higher priority mode interrupts the lower one.

The windshear mode has the highest priority. It lasts at least 5 seconds, even if the windshear condition is no longer present.

Glide Slope Repetition Rate

An input from the glide slope repetition rate circuit controls the variable glide slope annunciation repetition rate.

Voice menu Configuration

The airlines may select one of several aural message configurations. The program pins define the desired option.

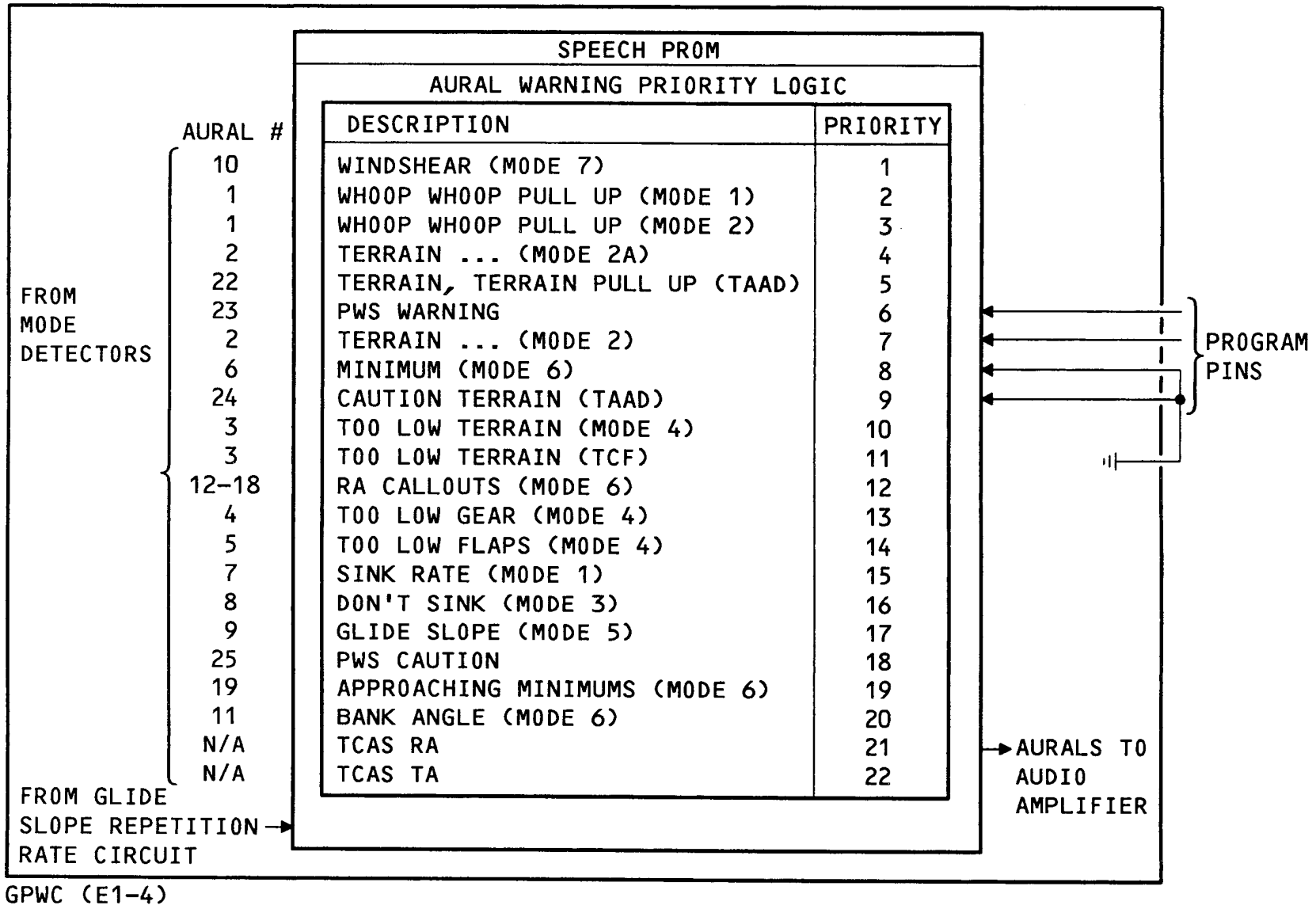


Figure 41 SPEECH PROM

BITE FUNCTION OPERATION

BITE Functions

The GPWC BITE:

- Monitors the validity of inputs
- Generates internal test commands
- Inhibits mode annunciations when an input or a GPWC function impairs the integrity of that mode
- Partially or completely inhibits the flight deck test for the same reasons
- When commanded by the BITE DECODER, generates the GPWC BITE callouts
- Sends EICAS messages through the EIUs

Inputs Monitored

BITE monitors the inputs from the following systems and LRU's:

- CMCS
- LRRA
- ADCS
- ILS
- FMCS
- IRS
- Stall warning cards
- CAPT. and FIO EFIS control panels Flap control units
- Landing gear lever
- All program pins.

Fault Memory

BITE stores faults in nonvolatile fault memory by flight legs. An input from the CMC defines the start of the flight legs. If the CMC input fails, the air/ground relay logic circuit define the flight legs.

Mode Inhibit

If an input or internal function impairs the integrity of a mode, BITE inhibits just that mode. All other modes continue to work.

Status

The CMC continuously sends the command summary word label 227 to the GPWC. This word is a request for status information or a command to run a flight deck test. In response, BITE sends the fault summary word label 350 to the CMC through the EIUs. This word includes detected failures.

Test Inhibit

Certain inputs inhibit parts or all the flight deck tests from the flight deck test sequencer.

Air/Ground Logic

The air/ground input:

- Inhibits flight deck tests in the air
- Defines the start and end of a flight leg if the CMC fails.

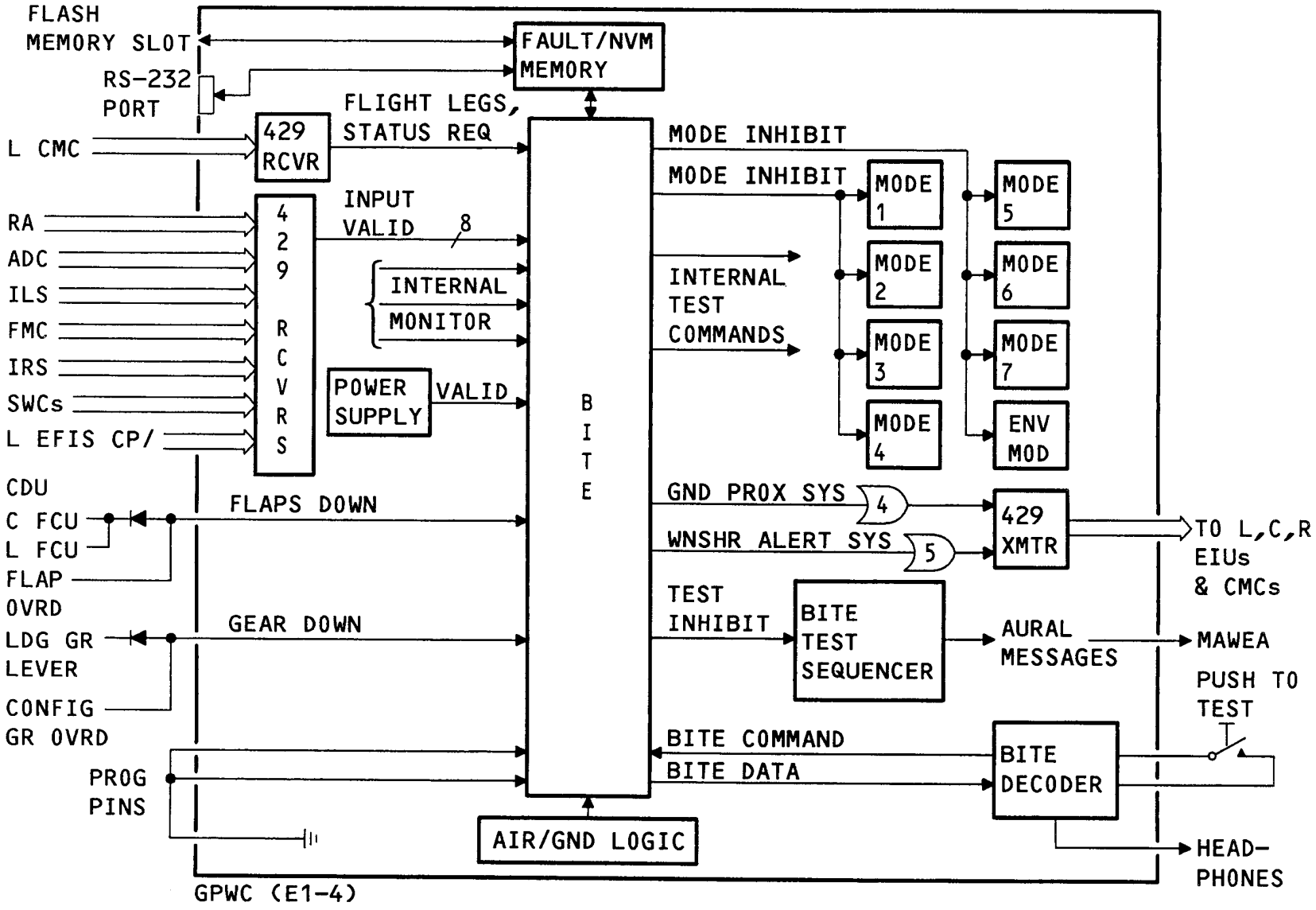


Figure 42 BITE FUNCTION OPERATION

FLIGHT DECK SELF-TESTS - 1

Flight Deck Self-Test Description

The GPWS has two flight deck self-tests:

- The CDU confidence test
- The CDU ground test.

Both tests are the same. They show the same indications. The only difference is the CMC menu used to access the tests.

An IN-AIR input from the air/ground relay prevents the self-tests in the air.

CDU Confidence Test

To start a CDU confidence test, select CONFIDENCE TESTS on the CDU CMC menu page and push the line select key next to < GPWC. A test pre-condition screen will show. After completion of this precondition, push the start test LSK. If the GPWS passes the test, the CDU shows PASS opposite GPWC.

If there is a fault, the CDU shows FAIL. To get to the CONFIDENCE TEST MSG page, push the line select key next to FAIL. This page gives more details on the failure.

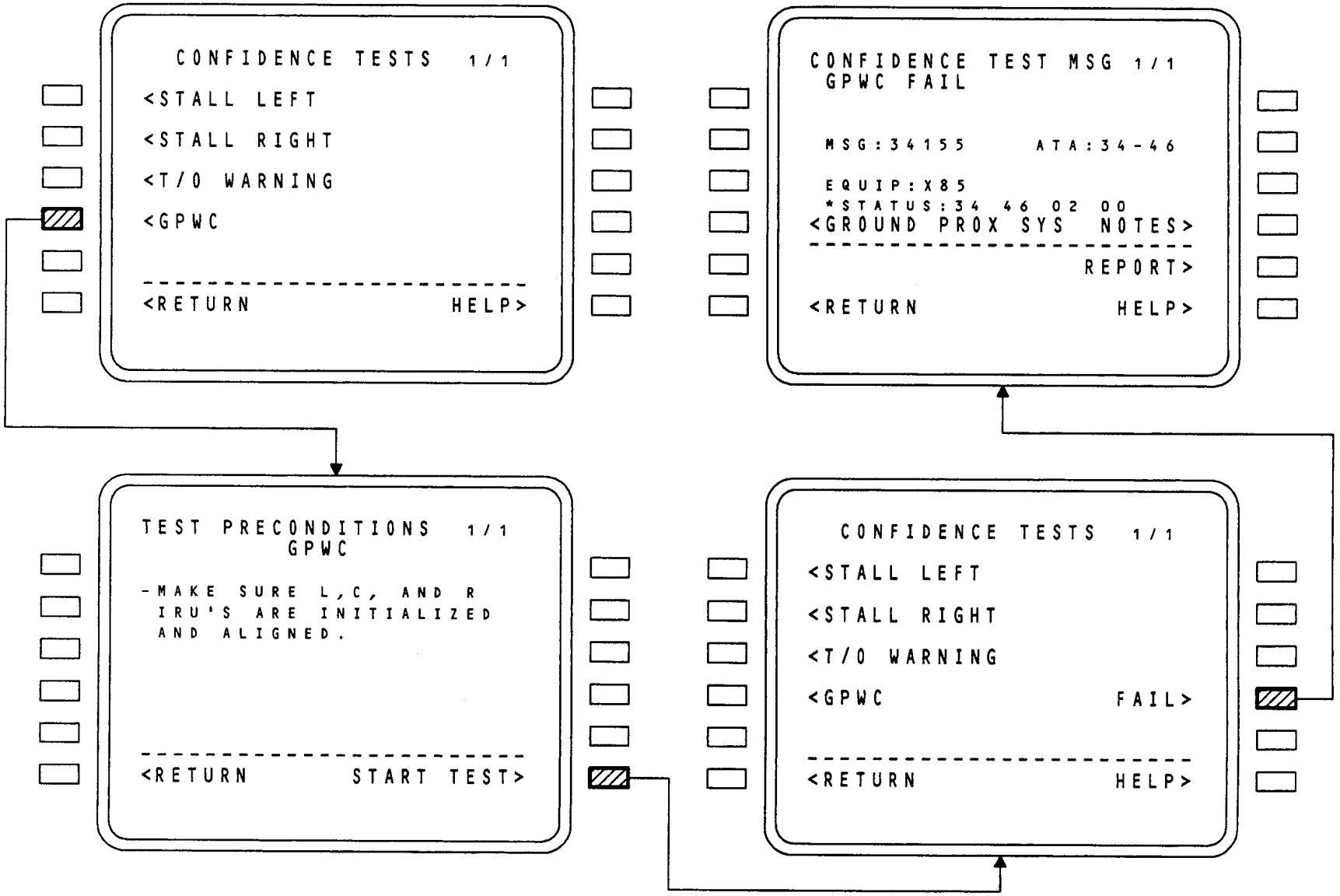


Figure 43 FLIGHT DECK SELF-TESTS - 1

FLIGHT DECK SELF-TESTS - 2

Ground Test

To start a GPWC ground test, first access the CMC chapter 34 navigation radios ground test pages on the CDU. Push the LSK next to GPWC. A precondition screen will come up. After completion of this precondition, push the START TEST LSK. This brings up the ground tests main menu and shows ”In progress” over GPWC.

An input from the air/ground logic inhibits the ground test in flight.

Ground Test Results

The word PASS opposite GPWC shows that the system passed the test. The word FAIL shows a failure in the system.

Push the LSK next to FAIL to show the GROUND TEST MSG page. This page gives additional data about the test failure.

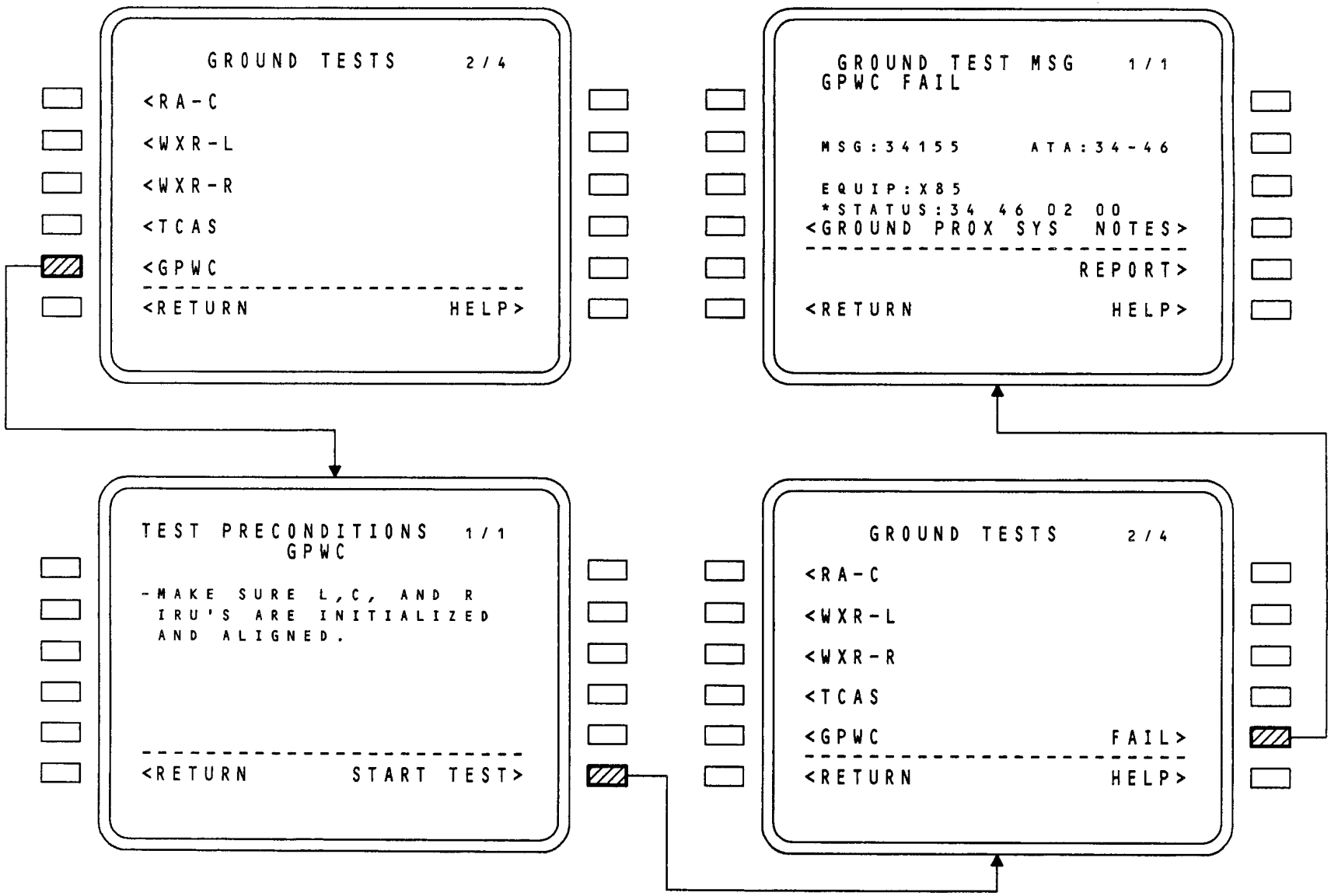


Figure 44 FLIGHT DECK SELF-TESTS - 2

LEVEL 1 - SELF TEST

General

The ground proximity warning system (GPWS) has six levels of self test. Each level provides different information about the GPWS. The six levels of self test are:

- 1 - GO/NO-GO operational test
- 2 - Current faults
- 3 - System configuration
- 4 - Fault history
- 5 - Alert/warning history
- 6 - Discrete input test.

Level one is a GO/NO-GO operational test. A level one test provides visual and aural annunciations on the flight deck.

Level One Test Preparation

These conditions must be true to do a level one operational test of the GPWS:

- Airplane on ground
- GPWS power on
- EFIS ND mode selector in correct mode (expanded VOR, APP, or MAP or centered MAP)
- TERR switch on EFIS control panel (CP) selected.

Level One Test Procedure

Select ground or confidence test from the central maintenance computer (CMC) to begin a level one test. A level one test first does a test of these configuration conditions:

- Program pin parity
- Airplane configuration database validity
- Airplane type.

If the test finds a configuration fault, self test annunciates the fault ans self test ends. If the GPWS passes the configuration test, the level one test continues.

Training Information Point

You can start a level one self test from the front panel of the GPWC, but you cannot see the flight deck annunciations. Use the CMC to start a test of the GPWS.

Level One Test - Normal Indications

These messages should show at some time during the level one self test:

- EICAS Advisory – GND PROX SYS
- EICAS Advisory – WINDSHEAR SYS
- EICAS Advisory – TERR POS
- EICAS Status – GND PROX SYS
- EICAS Status – WINDSHEAR REAC
- EICAS Status – TERR SYS
- Amber ND alert message – TERR TEST
- Amber ND alert message - TERR FAIL

These visual and aural annunciations show for a normal level one test:

- ND system message TERR TEST shows in cyan
- Ground proximity warning light on and aural message GLIDESLOPE
- Master warning lights on, PFD message PULL UP (red), and aural message PULL UP
- Master warning lights on, PFD message WINDSHEAR (red), and aural message WINDSHEAR, WINDSHEAR, WINDSHEAR
- Terrain test pattern shows on ND for 12 seconds
- Master warning lights on, PFD message PULL UP (red), TERRAIN alert message (red) on NDs, and aural message TERRAIN, TERRAIN, PULL UP.
- Ground proximity light on and TERRAIN alert message (amber) on NDs
- Terrain test pattern goes off.
- Aural message SINKRATE

Level One Test - Normal Indications (cont.)

- Aural message PULL UP
- Aural message DONT SINK
- Aural message DONT SINK

- Aural message TOO LOW TERRAIN

Level One Test - Normal Indications (cont)

- Aural message TOO LOW GEAR
- Aural message TOO LOW FLAPS
- Aural message TOO LOW TERRAIN
- Aural message GLIDESLOPE
- Aural message BANK ANGLE, BANK ANGLE
- Mode 6 altitude callouts
- Aural message WINDSHEAR, WINDSHEAR, WINDSHEAR
- Aural message TOO LOW TERRAIN
- Aural message CAUTION TERRAIN, CAUTION TERRAIN
- Aural message TERRAIN, TERRAIN, PULL UP

Level One Self Test - Non-Normal Indications

The GPWS level one test fails for any of these conditions:

- The terrain test pattern does not show
- The TERR FAIL message on the ND stays on
- You do not see and hear all annunciations.

Training Information Point

Some GPWS modes have the same annunciations. If you do not see and hear all annunciations, the test fails.

GPWS Mode Failures

These aural messages annunciate for GPWS modes that do not function:

- GLIDESCOPE INOP
- GPWS INOP
- BANK ANGLE INOP
- CALLOUTS INOP
- WINDSHEAR INOP
- TERRAIN INOP.

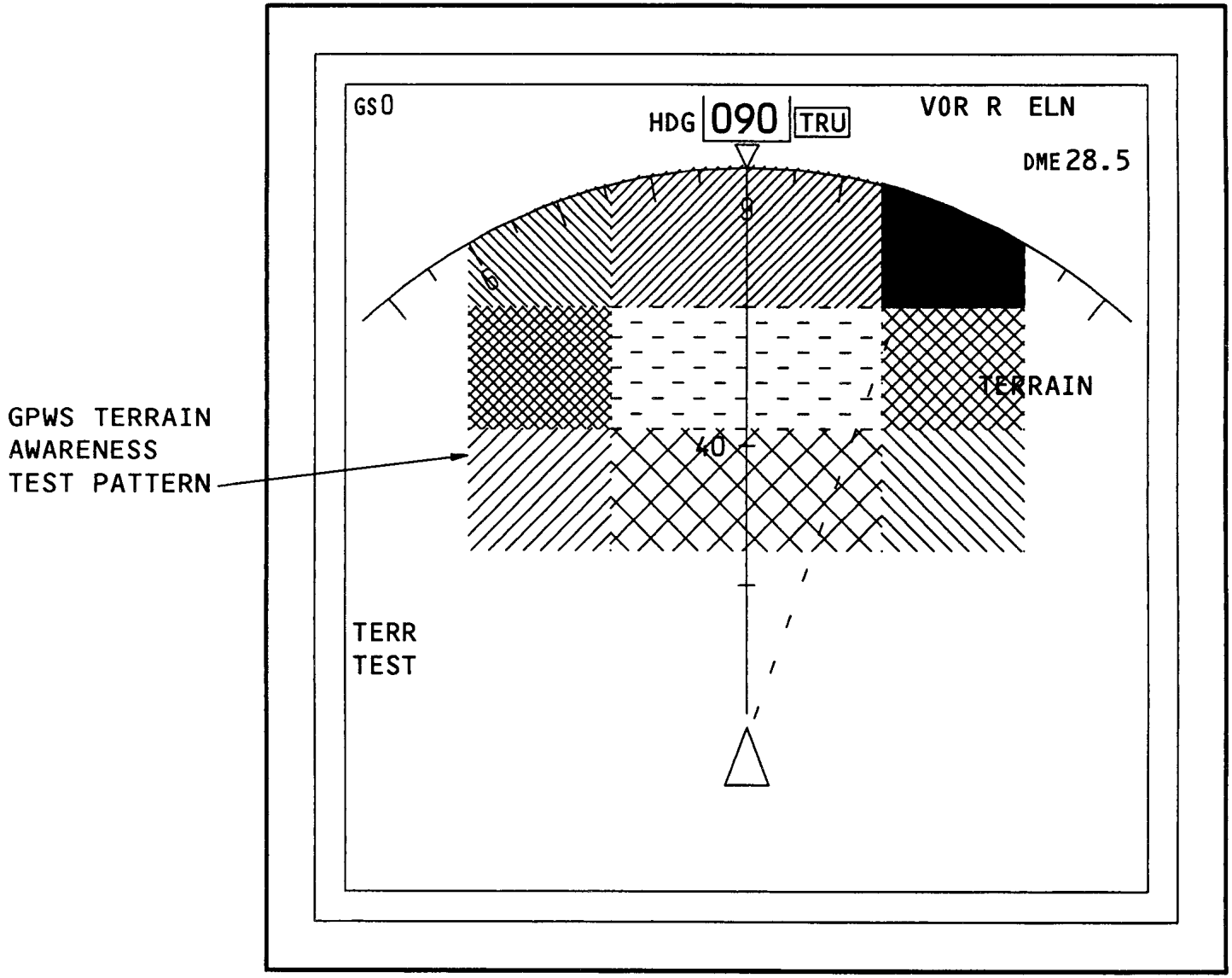


Figure 45 LEVEL 1 - SELF TEST

LEVELS 2 – 5 - SELF-TEST

General Description

The ground proximity warning computer (GPWC) has six levels of self test:

- 1 - GO/NO-GO operational test
- 2 -Current faults
- 3 - System configuration
- 4 - Fault history
- 5 - Alert/warning history
- 6 - Discrete input test.

Self test levels 2-6 access self test information not available through the control maintenance computer (CMC). Use a 600 ohm headphone to listen to the test information. Plug the headphone into the jack on the front panel of the GPWC.

Use the self test button on the front panel of the GPWC to access levels 2-6. The self test button has these two modes:

- Short cancel - push the button for less than two seconds
- Long cancel - push the button for more than two seconds.

Use the self test button for these functions:

- Start self test level one
- Go to the next item or flight leg within a test
- Go to the next self test level
- End the self test.

When a test level ends, the aural message PRESS TO CONTINUE annunciates. Push the self test button to go to the next test level. If you do not push the self test button within three seconds, self test ends.

Level Two Self Test - Current Faults

A level two test begins with the aural message CURRENT FAULTS. If there are no current faults, you hear the aural message NO FAULTS. If faults exist, the GPWC annunciates the faults one at a time. A short or long cancel ends the level two test.

Level Three Self Test - System Configuration

A level three test annunciates the GPWS configuration. A level three test begins with the aural message SYSTEM CONFIGURATION. A short cancel causes the test to go immediately to the next configuration item. A long cancel ends the level three test. A level three test provides this information:

- GPWC part number
- GPWC modification status
- GPWC serial number
- Application software version
- Configuration software version
- Terrain database version
- Envelope modulation database version
- Boot code version
- Aircraft type
- Audio menu
- Altitude callout menu number
- Selected options.

Level Four Self Test - Fault History

Level four self test annunciates the GPWS fault history over the last ten flights.

A level four test begins with the aural message FAULT HISTORY. If there are no faults in the flight history memory, you hear the aural message NO FAULTS. If there are faults in the flight history memory, you hear the most recent faults annunciate first. You hear the faults in this order:

- FLIGHT X (X is the most recent flight leg number)
- Internal faults for flight X
- External faults for flight X
- Go to next oldest flight leg and repeat.

A short cancel causes the test to go immediately to the next flight leg. A long cancel ends self test level four.

Level Five Self Test - Warning History

Level five self test annunciates GPWS alerts over the last ten flights.

Level Five Self Test - Warning History (cont)

A level five test begins with the aural message WARNING HISTORY. If there are no alerts in the flight history memory, you hear the aural message NO WARNINGS. If there are alerts in the flight history memory, you hear the most recent alerts first. You hear the alerts in this order:

- FLIGHT X (X is the most recent flight leg number)
- GPWS alerts for flight X
- Go to next oldest flight leg and repeat.

A short cancel cause the test to go immediately to the next flight leg. A long cancel ends self test level four.

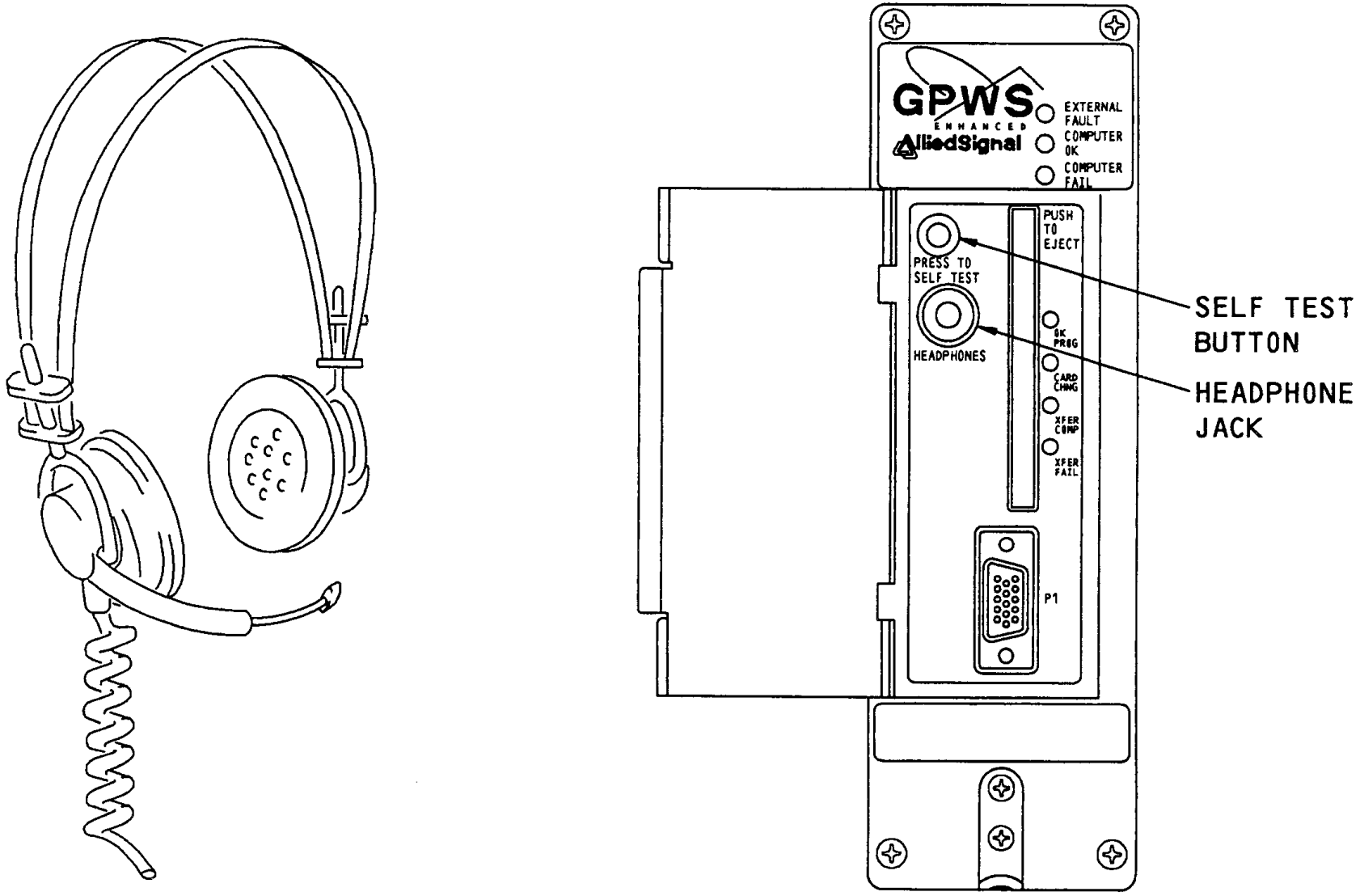


Figure 46 LEVELS 2 – 5 - SELF-TEST

LEVEL 6 - SELF TEST

General Description

The ground proximity warning computer (GPWC) has a level six discrete input test.

This test accesses test information not available from the central maintenance computer (CMC). Use a 600 ohm headphone to listen to the test information. Plug the headphone into the jack on the front panel of the GPWC.

Use the self test button on the front panel of the GPWC to access level six. The self test button has these two modes:

- Short cancel - push the button for less than two seconds
- Long cancel - push the button for more than two seconds.

Use the self test button for these functions:

- Start self test level one
- Go to the next item or flight leg within a test
- Go to the next self test level
- End the self test.

When a test level ends, the aural message PRESS TO CONTINUE annunciates. Push the self test button to go to the next test level. If you do not push the self test button within three seconds, self test ends.

Level Six Self Test - Discrete Input Test

A level six test checks changes in discrete inputs.

The test starts with the aural message DISCRETE TEST. If the state of a discrete input changes, you hear the new state of the discrete.

You hear the aural message DISCRETE INPUT TEST - PRESS TO CANCEL every 60 seconds. Push a short or long cancel to end the self test.

DISCRETE INPUT	INPUT SOURCE	ANNUNCIATIONS
- GEAR OVERRIDE SWITCH	P2 PANEL	LANDING GEAR DOWN LANDING GEAR UP
- FLAP OVERRIDE SWITCH	P2 PANEL	LANDING FLAPS NO LANDING FLAPS
- GLIDESLOPE OVERRIDE SWITCH	P2 PANEL	GLIDESLOPE CANCELLED GLIDESLOPE ENABLED
- TERRAIN OVERRIDE SWITCH	P2 PANEL	TERRAIN OFF TERRAIN ON
- TERRAIN RELAY 1	LEFT EFIS TERR SWITCH	TERRAIN RELAY 1 ON TERRAIN RELAY 1 OFF
- TERRAIN RELAY 2	RIGHT EFIS TERR SWITCH	TERRAIN RELAY 2 ON TERRAIN RELAY 2 OFF

LEVEL 6 DISCRETE INPUT TEST

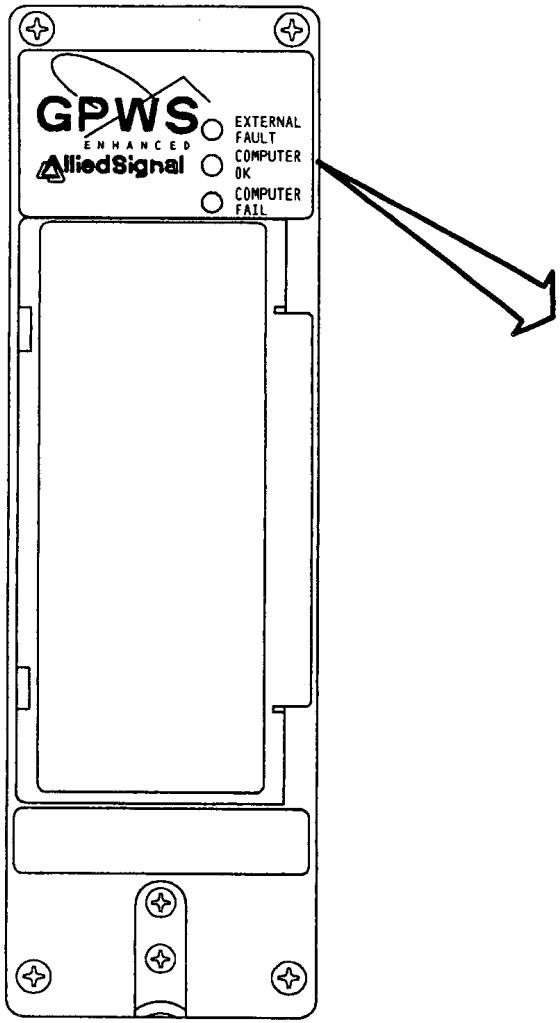
Figure 47 LEVEL 6 - SELF TEST

GPWS - STATUS LEDS

Purpose

There are three status LEDs on the front panel of the ground proximity warning computer (GPWC). These LEDs turn on when there is power to the GPWC. These LEDs are:

- External fault yellow
- Computer OK - green
- Computer fail - red.



EXTERNAL FAULT	COMPUTER OK	COMPUTER FAIL	CONDITION
OFF	OFF	OFF	GPWC POWER OFF
OFF	OFF	RED	GPWC INTERNAL FAULT
OFF	GREEN	OFF	NORMAL OPERATION
OFF	GREEN	RED	GPWC INTERNAL FAULT
YELLOW	OFF	OFF	GPWS EXTERNAL FAULT
YELLOW	OFF	RED	BOTH GPWC INTERNAL AND GPWS EXTERNAL FAULTS
YELLOW	GREEN	OFF	GPWS EXTERNAL FAULT
YELLOW	GREEN	RED	GPWC INTERNAL FAULT

Figure 48 STATUS LEDS

FLIGHT DECK EFFECTS

Purpose

This graphic contains a summary of all maintenance related flight deck effects.

Flight Deck Effects

Two status messages are available to show GPWS input and internal function faults:

- GND PROX SYS
- WINDWHEAR REAC.

The GND PROX SYS message indicates a failure of the ground proximity function. The WINDSHEAR REAC message indicates a failure of the windshear function.

Two EICAS advisory messages give the flight crew information about GPWS faults :

- GND PROX SYS
- WINDSHEAR SYS.

These advisory messages will show when the status messages show.

FLIGHT DECK EFFECT	TYPE	DESCRIPTION
GND PROX SYS	ADVISORY MESSAGE	FAULT CONDITION EXISTS IN THE GPWC
WINDSHEAR SYS	ADVISORY MESSAGE	FAILURE OF THE WINDSHEAR FUNCTION IN THE GPWC
GND PROX SYS	STATUS MESSAGE	FAULT CONDITION EXISTS IN THE GPWC
WINDSHEARREAC	STATUS MESSAGE	FAILURE OF THE WINDSHEAR FUNCTION IN THE GPWC

Figure 49 FLIGHT DECK EFFECTS

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