PFN NUMBER 011-9759
SEPTEMBER 2004

STUDENT GUIDE

FOR

UH-60 AUTOMATIC FLIGHT CONTROL SYSTEM

(AFCS)

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SEPTEMBER 2004

AUTOMATIC FLIGHT CONTROL SYSTEM

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This TSP supersedes None, Dated NA.

SECTION I. - INTRODUCTION

TERMINAL LEARNING OBJECTIVE:

At the completion of this lesson you will:

ACTION: Identify the characteristics of the Automatic Flight Control System (AFCS).

CONDITIONS: As an UH-60 Maintenance Test Pilot.

STANDARD: In Accordance with (IAW) TM 1-1520-237-10, TM 1-1520-237-23-2, TM 1-1520-237-MTF.

SAFETY REQUIREMENTS: Remove all watches, rings and other jewelry before operating, or maintaining electronic equipment.

RISK ASSESSMENT LEVEL: Low

ENVIRONMENTAL CONSIDERATIONS: There are no environmental concerns for this lesson.

EVALUATION: Evaluation will be accomplished with performance exam at the end of this module of instruction.

SECTION II. - PRESENTATION

A. ENABLING LEARNING OBJECTIVE ELO No. 1

ACTION: Identify the function of the Automatic Flight Control System (AFCS) and subsystems.

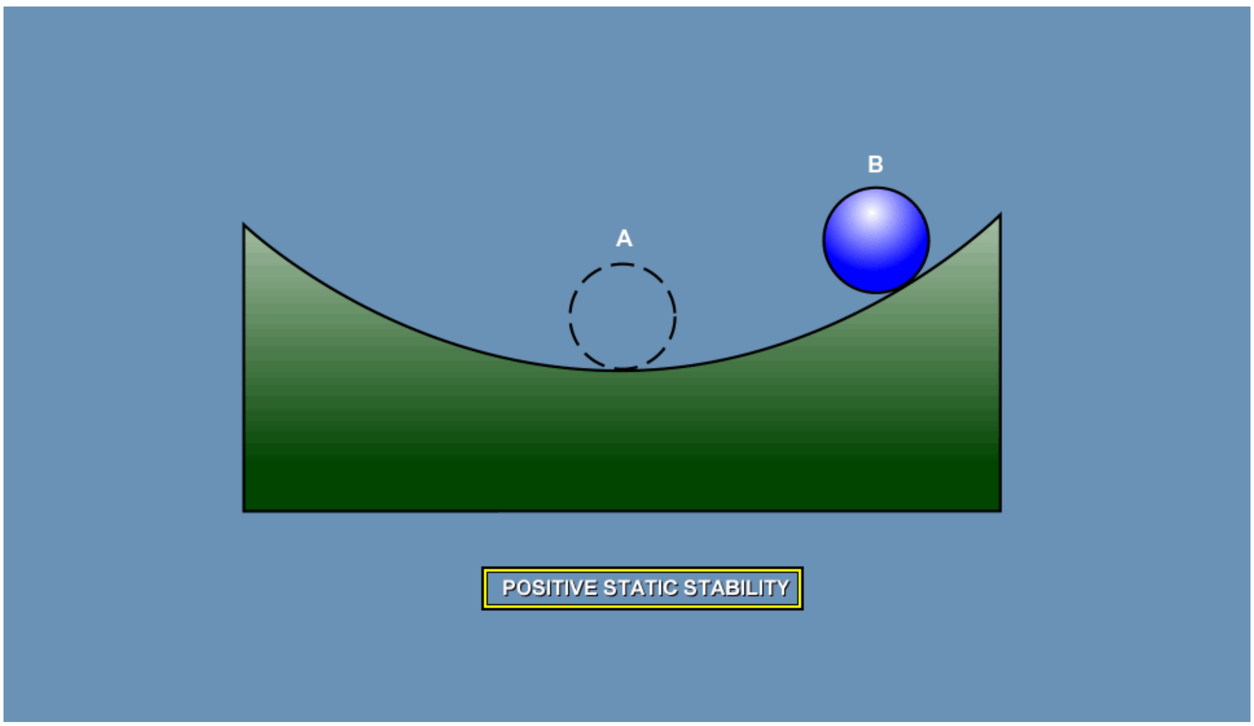
CONDITIONS: As an UH-60 Maintenance Test Pilot.

STANDARD: Using TM 1-1520-237-10, TM 1-1520-237-23-2, TM 1-1520-237-MTF, and TM 11-1520-237-23-2.

a. Overview

(1) Static Stability

Frame # 1005 (Positive Static Stability)



(a) Positive Static Stability

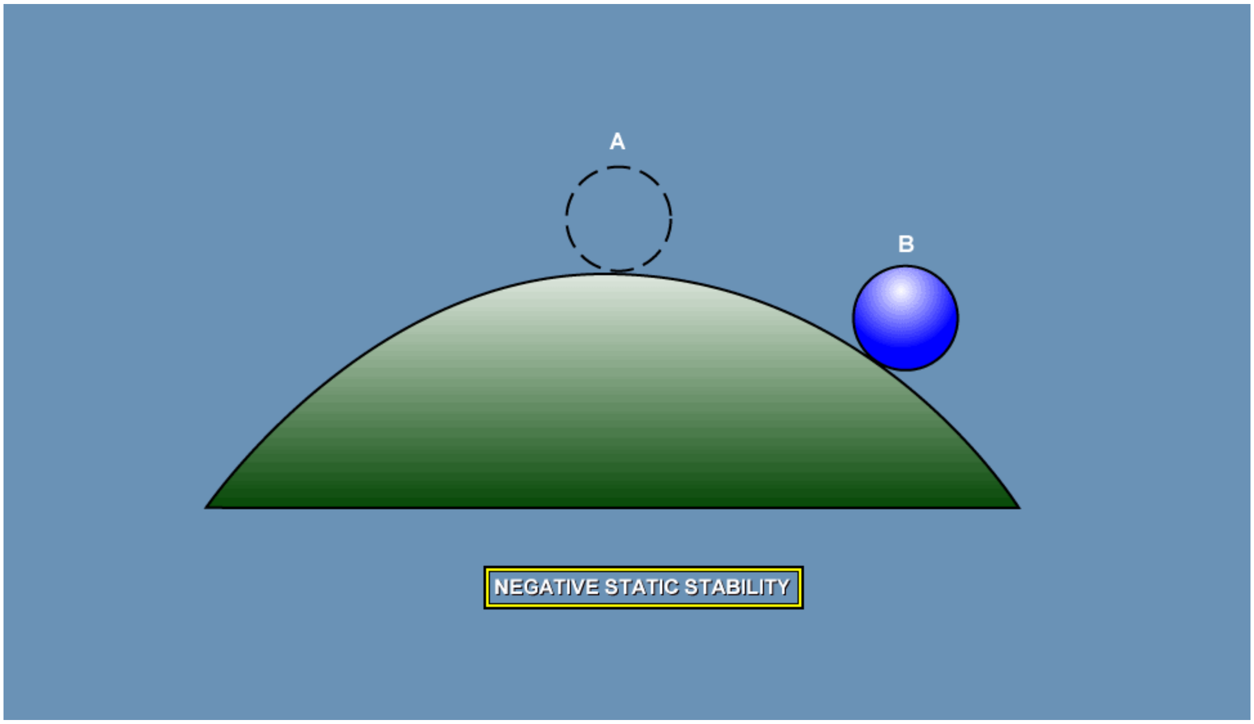
1) Positive static stability is when an object tends to return to its equilibrium position after it has been moved.

2) Point A shows the ball in equilibrium.

3) If the ball is moved to point B, it tends to roll back toward point A. This demonstrates positive static stability.

4) The ball may not actually return to point A, but it does tend to return.

Frame # 1005 (Negative Static Stability)



(b) Negative Static Stability

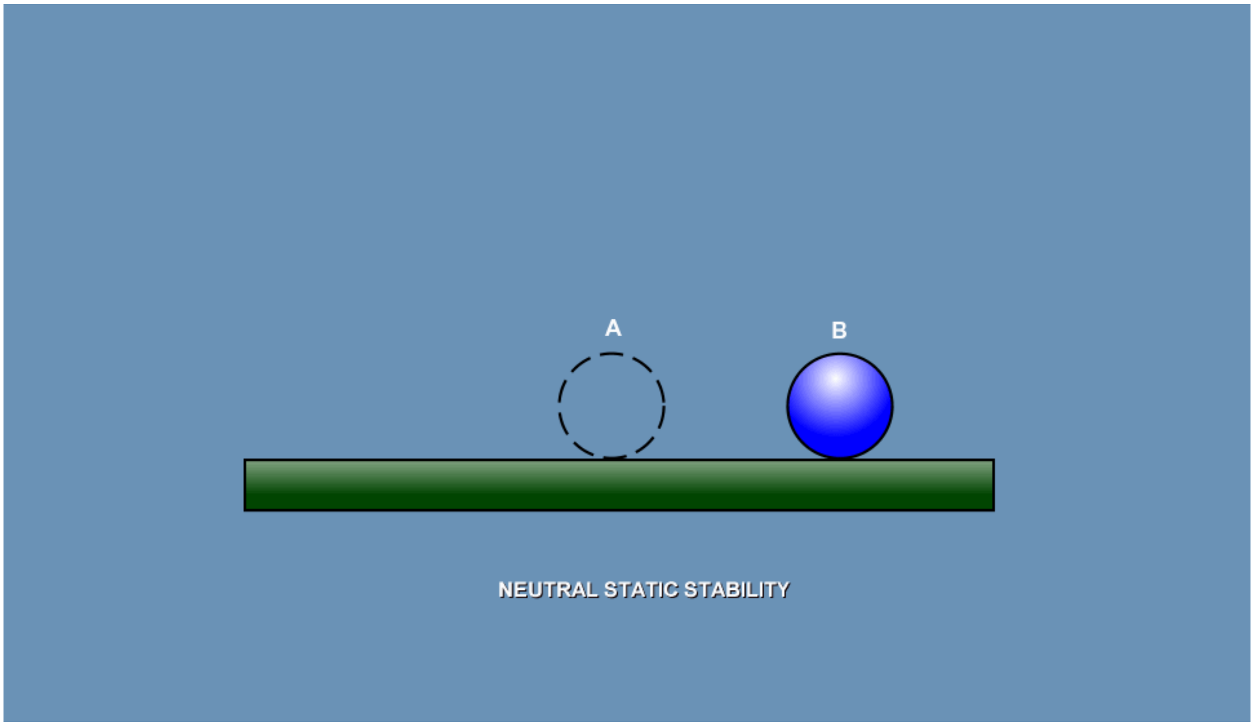
1) In demonstrating negative static stability think of an inverted bowl.

2) Point A is the equilibrium position.

3) The ball has been moved to point B. Now the ball tends to roll away from point A.

4) This tendency toward movement away from the equilibrium position demonstrates negative static stability.

Frame # 1005 (Neutral Static Stability)



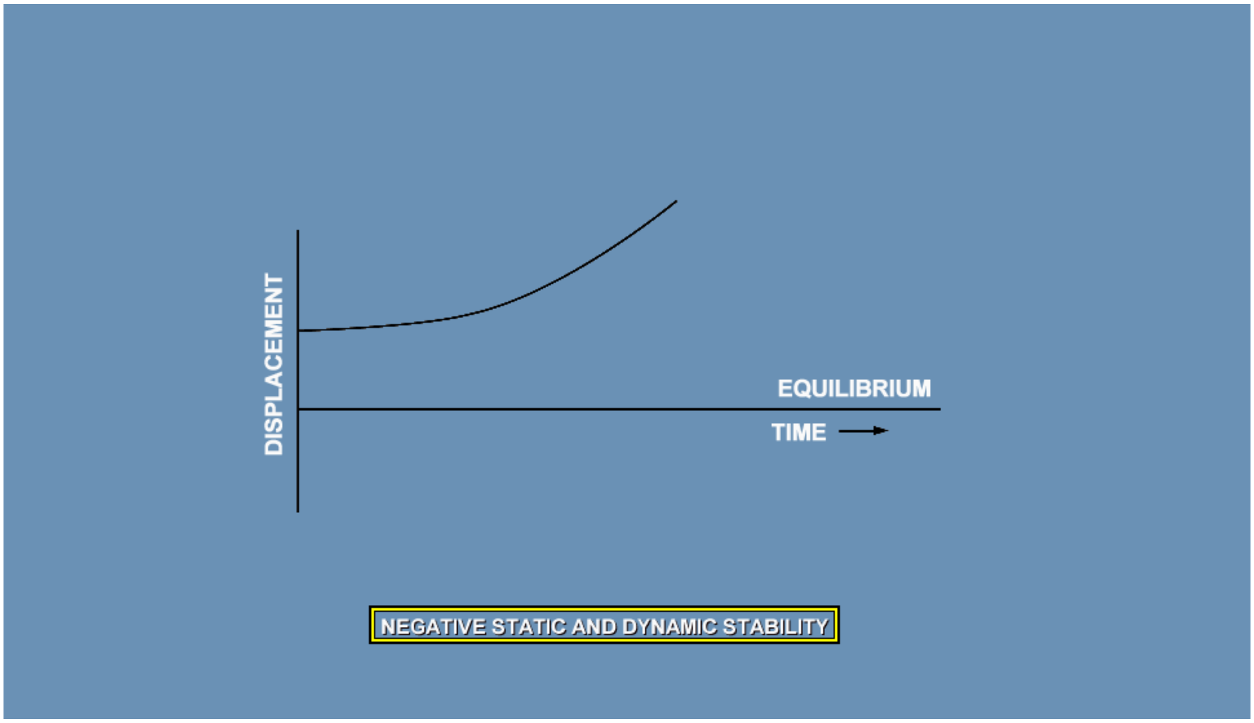
(c) Neutral Static Stability

1) In demonstrating Neutral Static Stability, the ball has been placed on a flat surface.

2) When the ball is moved to point B, it neither tends to return nor roll away from point A.

(2) Dynamic Stability/Non-oscillatory Motion

Frame # 1010 (Negative Static and Dynamic Stability)

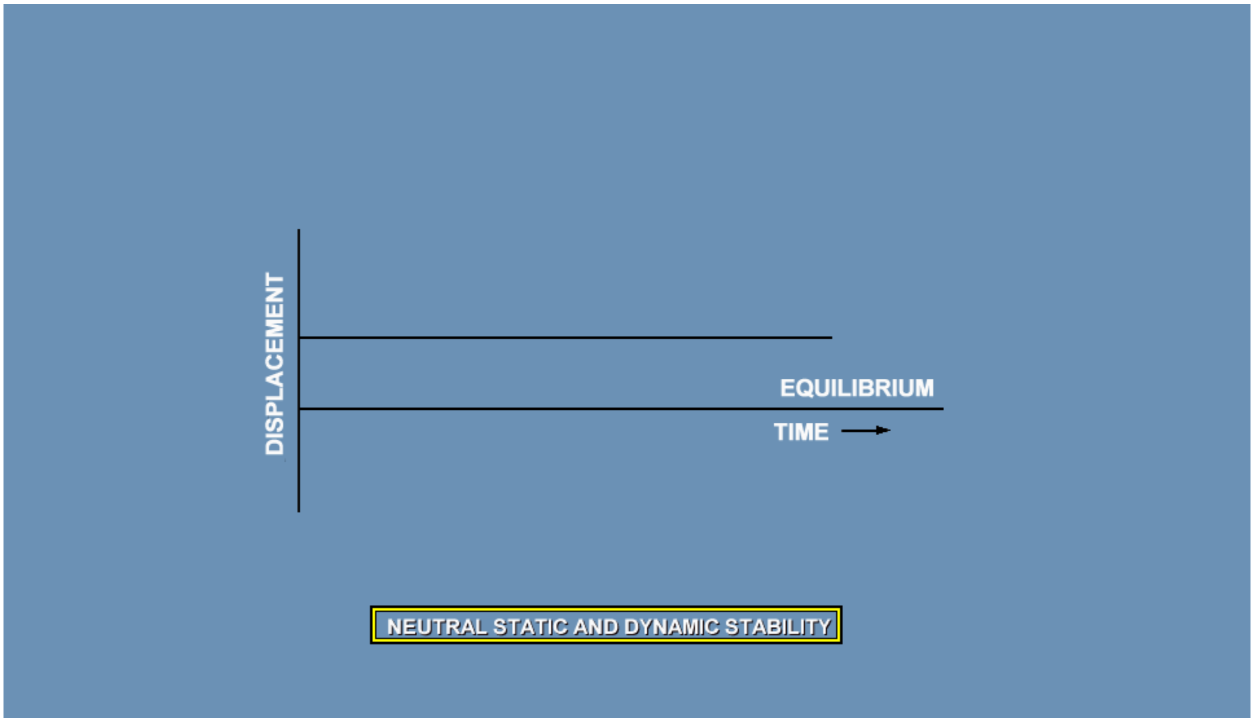


(a) Negative Static and Dynamic Stability

1) An object that possesses negative static stability tends to move away from its equilibrium position.

2) When an object does move away from its equilibrium position, it has non-oscillatory negative dynamic stability.

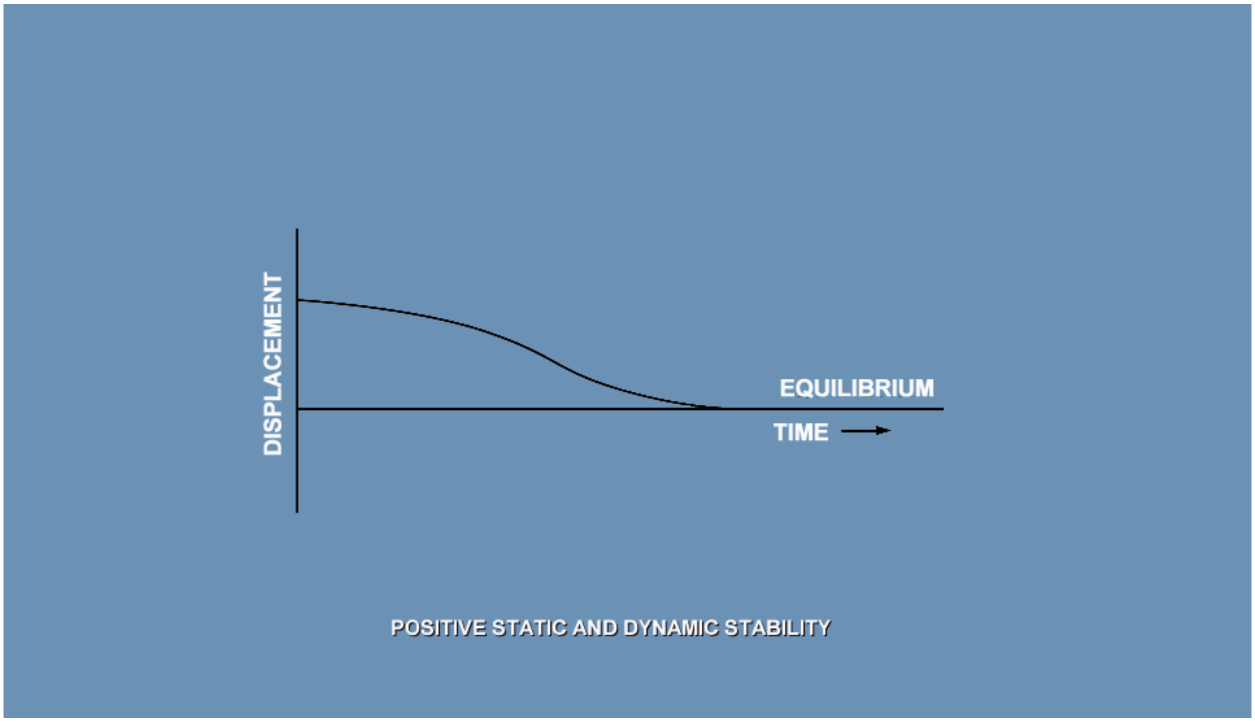
Frame # 1010 (Neutral Static and Dynamic Stability)



(b) Neutral Static and Dynamic Stability

1) When an object that has been displaced does not move toward or away from its equilibrium position, it has non-oscillatory neutral dynamic stability.

Frame # 1010 (Positive Static and Dynamic Stability)



(c) Positive Static and Dynamic Stability

1) When an object has positive static stability and strong positive dynamic stability, the result is nonoscillatory positive dynamic stability.

2) This motion is called deadbeat damping.

3) Dynamic stability is particularly stressful on the structure of the aircraft.

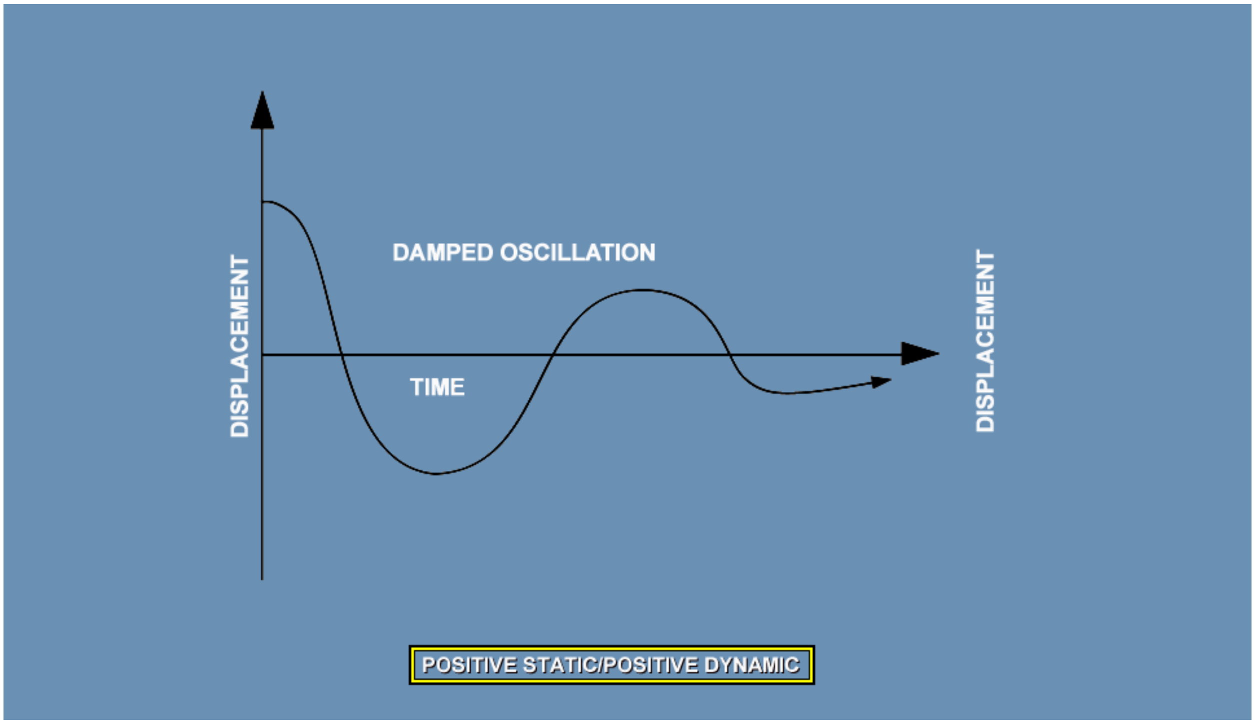
4) This stress would be similar to a car on which the springs had been replaced with steel blocks between the frame and axle.

5) When the car is driven over a railroad crossing, the steel blocks do not give and the energy is absorbed at once.

6) If this condition were allowed to continue, material failure would eventually occur.

(3) Dynamic Stability/Oscillatory Motion

Frame # 1015 (Positive Static/Positive Dynamic)



(a) Positive Static/Positive Dynamic

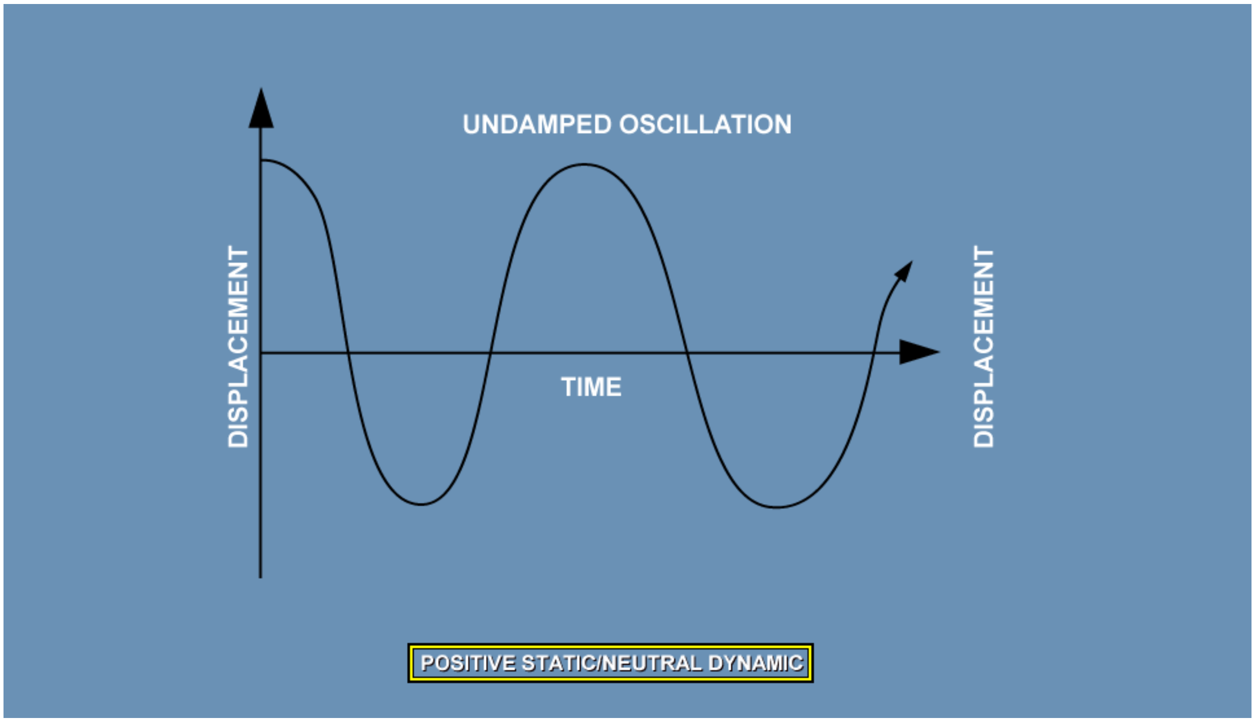
1) Positive static stability is when a displaced object tends to return to its equilibrium position.

2) This motion continues but diminishes until the object comes to rest at its equilibrium position.

3) A decrease in the amplitude of the oscillations indicates that the object has positive dynamic stability.

4) When an aircraft has positive static and dynamic stability, it tends to return to its equilibrium point over a period of time.

Frame # 1015 (Positive Static/Neutral Dynamic)



(b) Positive Static/Neutral Dynamic

1) Positive static, neutral dynamic stability is when an object that has been displaced moves toward the equilibrium position and overshoots it.

2) Positive static stability makes the object move back toward the equilibrium position.

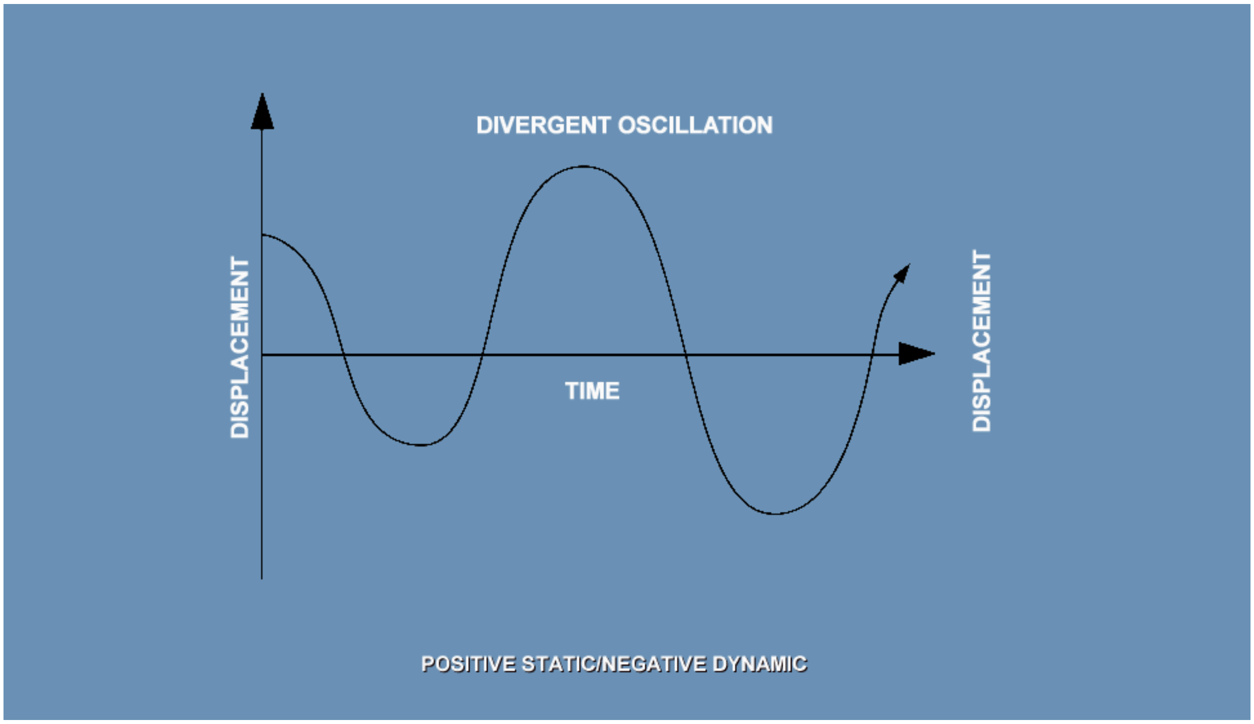
3) Again, the object overshoots the equilibrium position, and its oscillations are equal to the oscillations in the first displacement.

4) As time passes, the amplitude of the oscillations are the same on both sides of the equilibrium position.

5) The object never comes to rest.

6) Because the amplitude of the oscillations neither increases or decreases, the object has neutral dynamic stability.

Frame # 1015 (Positive Static/Negative Dynamic)



(c) Positive Static/Negative Dynamic

1) Positive static and negative dynamic stability has increasing amplitude of the oscillations as time passes indicate negative dynamic stability.

2) Lines drawn tangent to the top and bottom of each oscillation diverge.

(4) AFCS Overview

Frame # 1020 (AFCS Overview FLASH)

(a) The AFCS enhances the stability and handling qualities of the helicopter using conventional helicopter flight controls and reduces pilot workload by providing dynamic stability in which porpoising, rocking, and fishtailing or skidding are reduced or eliminated.

(5) AFCS Breakdown

(a) The Automatic Flight Controls System (AFCS) is an electrohydromechanical system.

(b) It provides inputs to the flight controls system to assist the pilot in maneuvering, handling, and also provides oscillation damping (dynamic stability) to maintain desired attitude, speed, and heading (static stability) of the helicopter.

(c) The Automatic Flight Control System (AFCS) is comprised of four major subsystems:

1) Stability Augmentation System (SAS)

a) The analog stability augmentation system, identified as SAS 1, provides short term correction and rate damping in the pitch, roll and yaw axis and also provides limited attitude hold in the roll axis.

b) The SAS amplifier is the central controller for SAS 1 operation and has no diagnostic capability.

c) The digital AFCS system provides the following functions: Digital stability augmentation system, flight path stabilization and trim system.

d) The SAS/FPS computer is the central controller for all the digital AFCS functions and has diagnostic capability.

e) The digital stability augmentation system, identified as SAS 2, provides short term correction and rate damping in the pitch, roll and yaw axis and also provides limited attitude hold in the roll axis.

2) Flight Path Stabilization (FPS)

a) The Flight Path Stabilization System (FPS) provides attitude hold in the pitch and roll axis and heading hold in the yaw axis at airspeeds below 60 knots.

b) At airspeeds above 60 knots, it also provides airspeed hold and turn coordination.

C) The following systems must be on and operational for FPS to function at 100%: SAS 1 and/or SAS 2, Boost, and TRIM. Stabilator in the AUTO mode enhances FPS operation, but is not required.

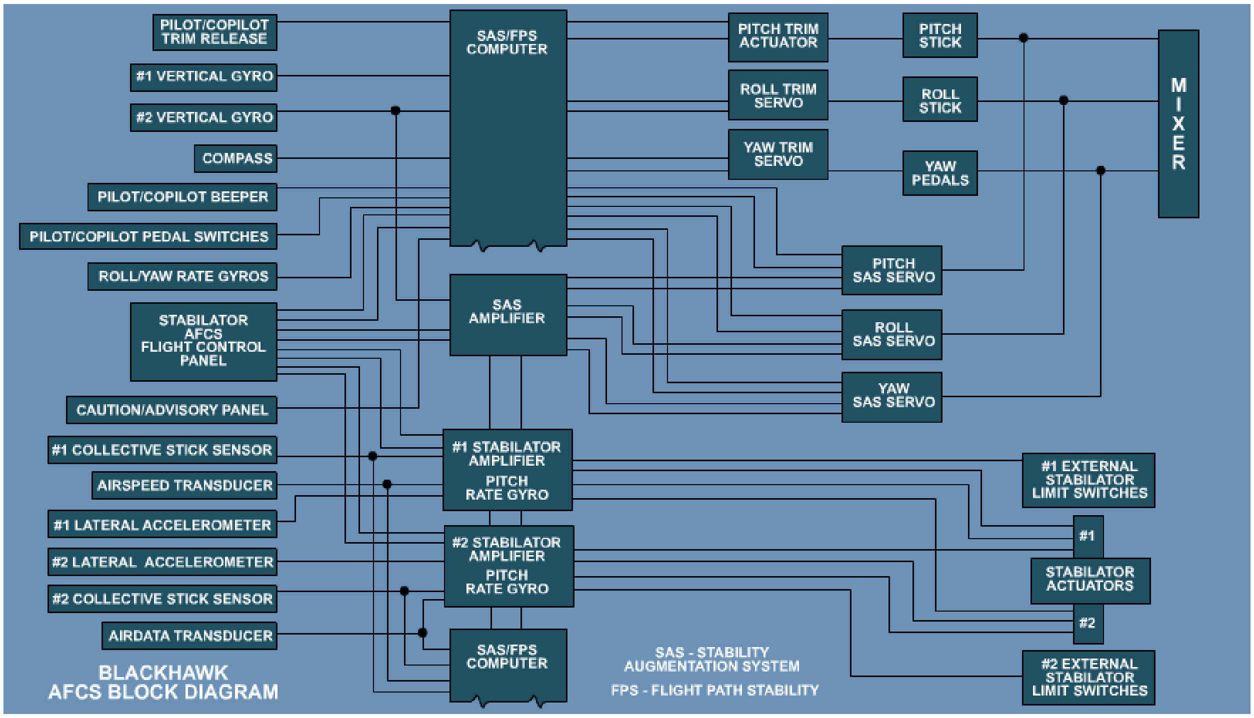
3) Trim System

a) The Trim system provides a cyclic (pitch and roll) stick and pedal (yaw) flight control force feel, and position hold and damping.

4) Stabilator Control System

a) The stabilator control system provides the helicopter with stability in the pitch axis by controlling the position of the horizontal stabilator.

Frame # 1027 (Simplified Schematic)



(6) The above schematic is a basic overview of the Automatic Flight Control System.

(7) Dynamic Stability of the AFCS

Frame # 1030 (Dynamic Stability of the AFCS)

	SAS	FPS	
	RATE DAMPING + PSEUDO ATTITUDE HOLD	AIRCRAFT TRIM	
	SHORT TERM STABILITY	LONG TERM STABILITY	STABILATOR
LONGITUDINAL (PITCH)	✓	✓	✓
LATERAL (ROLL)	✓	✓	—
DIRECTIONAL (YAW)	✓	✓	—

(a) Damping or dynamic stability capabilities of the AFCS.

(8) AFCS Sensors

Frame # 1035 (AFCS Sensors)

SENSOR	SIGNAL TO	PURPOSE
AIRSPEED TRANSDUCER	1. NO. 1 STAB AMP 2. SAS/FPS COMPUTER	a. AUTOMATIC CONTROL CIRCUITS b. TEST CIRCUIT DISABLE c. BUFFERED SIGNAL TO NO. 1 STAB AMP a. AIRSPEED HOLD b. AUTOMATIC COORDINATED TURN (LOGIC)
AIR DATA TRANSDUCER	1. COMMAND INSTRUMENT SYSTEM 2. NO. 2 STAB AMP 3. SAS/FPS COMPUTER	a. AIRSPEED REFERENCE b. ALTITUDE REFERENCE c. ALTITUDE RATE REFERENCE a. AUTOMATIC CONTROL CIRCUITS b. BUFFERED SIGNAL TO NO. 1 STAB AMP AIRSPEED COMPUTER
NO. 1 PITCH RATE GYRO	1. NO. 1 STAB SYSTEM 2. SAS AMP	PITCH STABILITY NO. 1 SAS PITCH STABILITY
NO. 2 PITCH RATE GYRO	1. NO. 2 STAB SYSTEM 2. SAS/FPS COMPUTER	PITCH STABILITY a. NO. 2 SAS PITCH STABILITY PITCH FPS
NO. 1 COLLECTIVE STICK POSITION SENSOR	1. NO. 1 STAB AMP 2. SAS/FPS COMPUTER	AUTOMATIC CONTROL CIRCUITS YAW FPS CIRCUITS
NO. 2 COLLECTIVE STICK POSITION SENSOR	1. NO. 2 STAB AMP 2. SAS/FPS COMPUTER 3. COMMAND INST SYS	AUTOMATIC CONTROL CIRCUITS YAW FPS COMPARE CIRCUITS COLLECTIVE POSITION SYSTEM
NO. 1 LATERAL ACCELEROMETER	NO. 1 STAB AMP	a. AUTOMATIC CONTROL CIRCUITS b. FILTERED AND NULLED SIGNAL TO: 1. SAS 1 AUTOMATIC TURN COORDINATION 2. SAS/FPS COMPUTER AUTOMATIC TURN COORDINATION SAS AND FPS
NO. 2 LATERAL ACCELEROMETER	NO. 2 STAB AMP	a. AUTOMATIC CONTROL CIRCUITS b. FILTERED AND NULLED SIGNAL TO SAS/ FPS COMPUTER COMPARE LOGIC

(a) Various sensors located on the aircraft, supply input to the computers that assist the pilot in controlling the aircraft in the heading, airspeed, attitude, and turn coordination.

Frame #1036 (AFCS SENSORS CONT'D #2)

SENSOR	SIGNAL TO	PURPOSE
NO. 1 VERTICAL GYRO CN-1314/A	1. DOPPLER NAV 2. C/P VSI (NORM) 3. P/VSI (ALT) AND COMMAND INST SYS (ALT) 4. SAS/FPS COMPUTER	ATTITUDE REFERENCE ATTITUDE INDICATION a. ATTITUDE INDICATION b. ATTITUDE REFERENCE a. PITCH ATTITUDE HOLD b. SAS 2 COMPARE (RATE)
NO. 2 VERTICAL GYRO CN-1314/A	1. P/VSI (NORM) AND COMMAND INST SYS (NORM) 2. C/P VSI (ALT) 3. SAS/FPS COMPUTER	a. ATTITUDE INDICATION b. ATTITUDE REFERENCE ATTITUDE INDICATION PITCH ATTITUDE COMPARE
NO. 1 VERTICAL GYRO CN-1314/A	1. DOPPLER NAV 2. C/P VSI (NORM) 3. P/VSI (ALT) AND COMMAND INST SYS (ALT) 4. SAS/FPS COMPUTER	ATTITUDE REFERENCE ATTITUDE INDICATION a. ATTITUDE INDICATION b. ATTITUDE REFERENCE a. ROLL ATTITUDE HOLD b. SAS 2 COMPARE (RATE) c. TURN COORDINATION
NO. 2 VERTICAL GYRO CN-1314/A	1. P/VSI (NORM) AND COMMAND INST SYS (NORM) 2. C/P VSI (ALT) 3. SAS/FPS COMPUTER 4. SAS/FPS COMPUTER	a. ATTITUDE INDICATION b. ATTITUDE REFERENCE ATTITUDE INDICATION ROLL ATTITUDE COMPARE a. ROLL STABILIZATION (DERIVED RATE FOR SAS 1)

Frame #1037 (AFCS SENSORS CONT'D #3)

SENSOR	SIGNAL TO	PURPOSE
AN/ASN - 43 COMPASS GYRO CN-998	1. DOPPLER NAVIGATION 2. VHF OMNIDIRECTIONAL RANGE 3. COMMAND INSTRUMENT SYSTEM 4. PILOT AND COPILOT HSI 5. SAS/FPS COMPUTER	HEADING REFERENCE HEADING REFERENCE HEADING REFERENCE HEADING INDICATION (COMPASS CARDS) a. HEADING HOLD b. TURN COORDINATION c. SAS 2 COMPARE (RATE)
ROLL RATE GYRO NO. 1 YAW RATE GYRO NO. 2 YAW RATE GYRO	SAS/FPS COMPUTER SAS AMP SAS/FPS COMPUTER	SAS 2 ROLL STABILITY YAW STABILITY SAS 1 YAW STABILITY SAS 2

(9) Inner Loop vs. Outer Loop

(a) The inner and outer loops are independent of each other.

(b) INNER LOOP: (SAS 1, SAS 2) Very fast, limited authority, rate dampening system that does not move the stick.

- Fights changes in aircraft motion with 10% authority at a rate of 100%/sec

(c) OUTER LOOP: (TRIM, FPS) Position control system.

- Long-term stability.
- Tries to maintain desired attitude, heading, airspeed or trim position with 100% authority at a rate of 10%/sec.

b. Stabilator Airflow Relationships

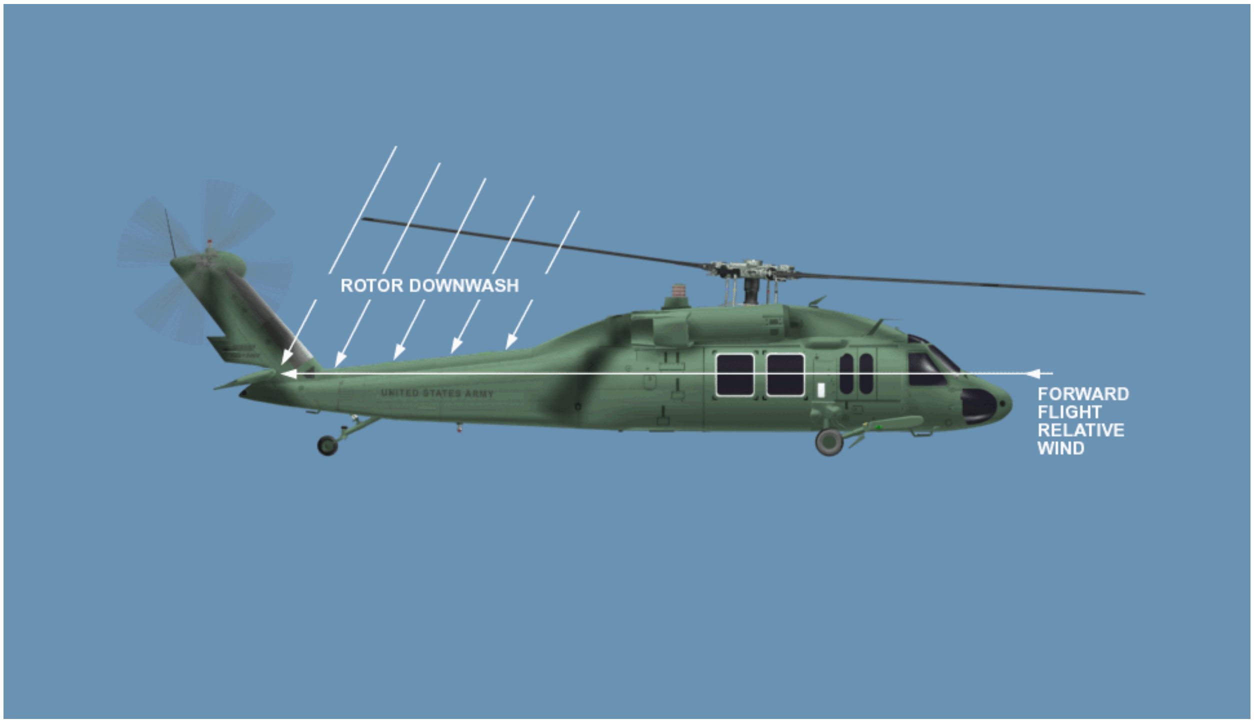
Frame #1055 (Stabilator Operation in Relation to Airflow)

(1) In A Hover

(a) In a hover the stabilator slews full down when airspeed is low (below 40 knots).

(2) Forward Flight

Frame #1060 (Forward Flight)



(a) The stabilator has a decreased angle of incidence with increased airspeed for improved static stability.

(b) In forward flight, the direction of the relative wind is influenced by the pitch attitude.

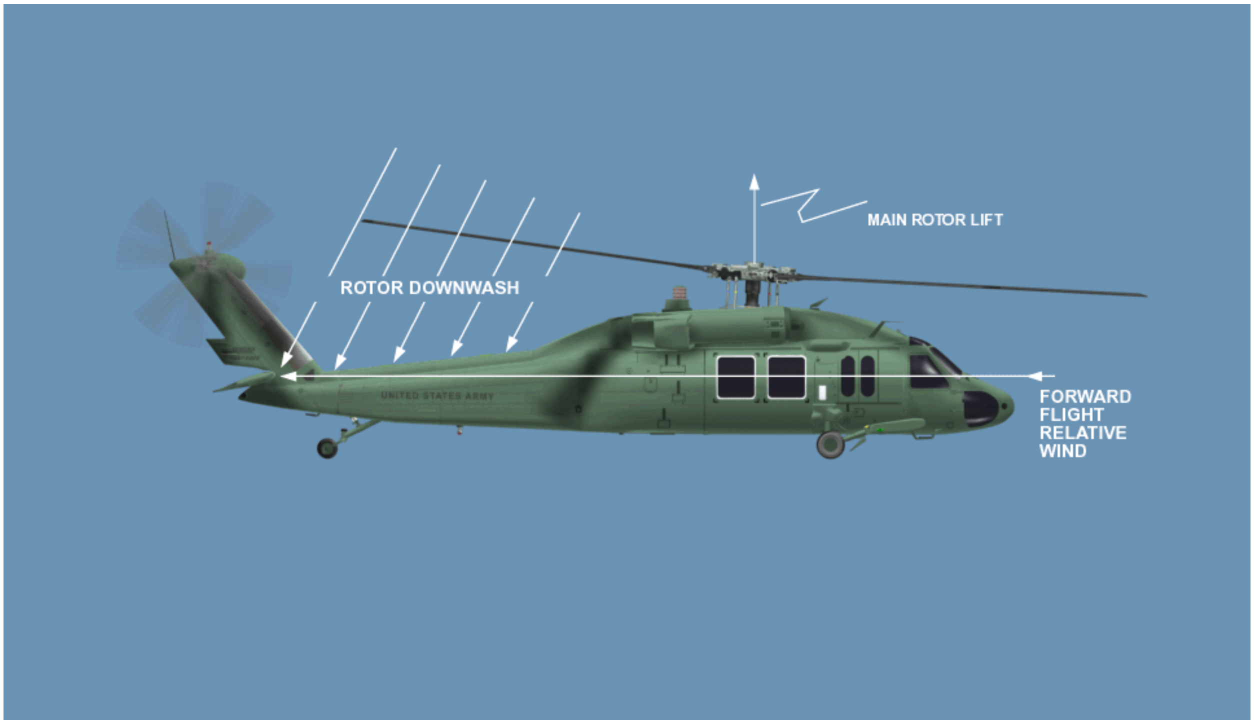
(c) Changes in pitch result in increased or decreased lift by the stabilator.

(d) The resulting induced upward or downward flow on the stabilator will return the aircraft to its initial condition.

(e) This is purely aerodynamic, there are no electronics involved.

(3) Collective Coupling

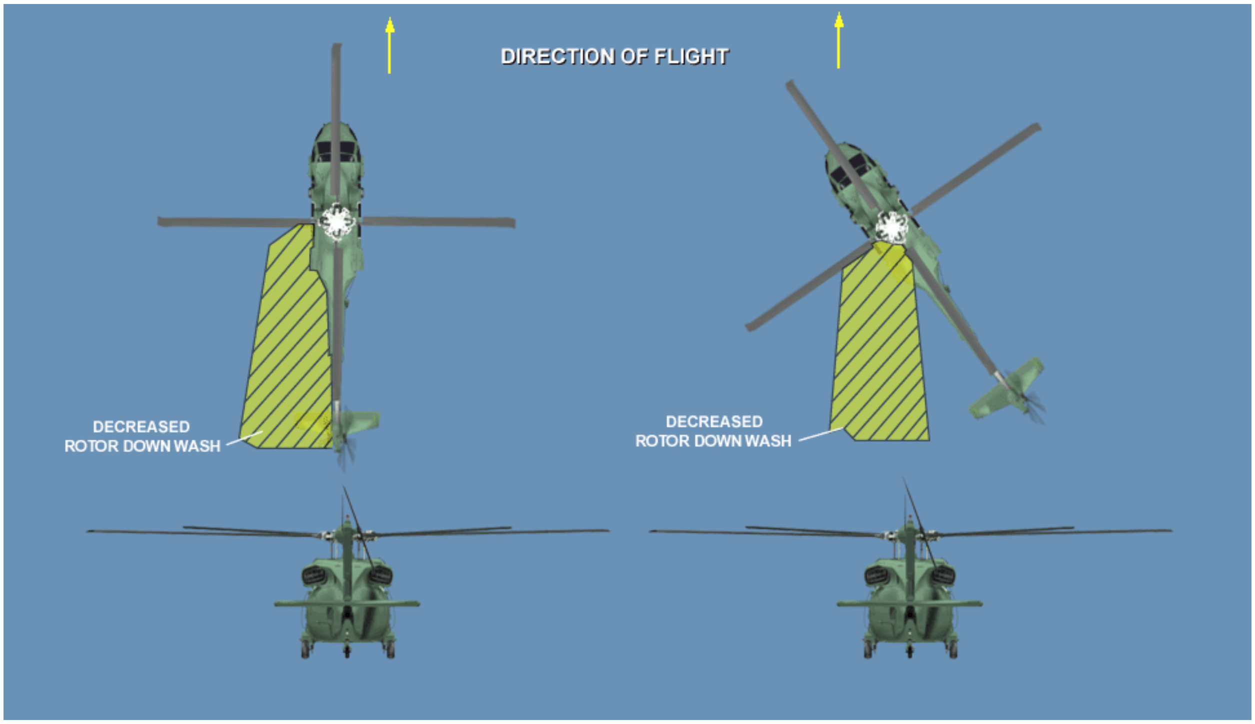
Frame #1065 (Collective Coupling)



(a) A collective coupling minimizes pitch attitude excursions by driving the stabilator in a direction opposite of the collective movement.

(4) Sideslip to Pitch Coupling

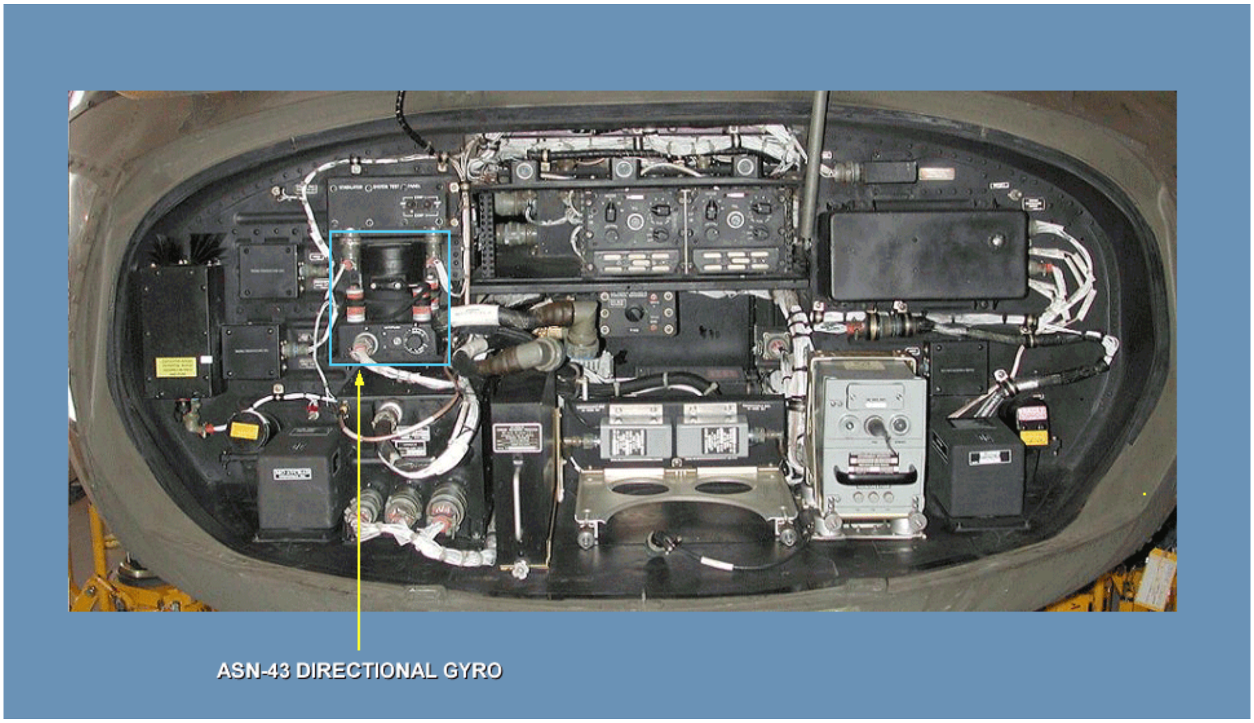
Frame #1070 (Sideslip to Pitch Coupling)



(a) The stabilator programs up or down when the helicopter is placed out of trim.

c. Components

Frame #1105 (Directional Gyro)

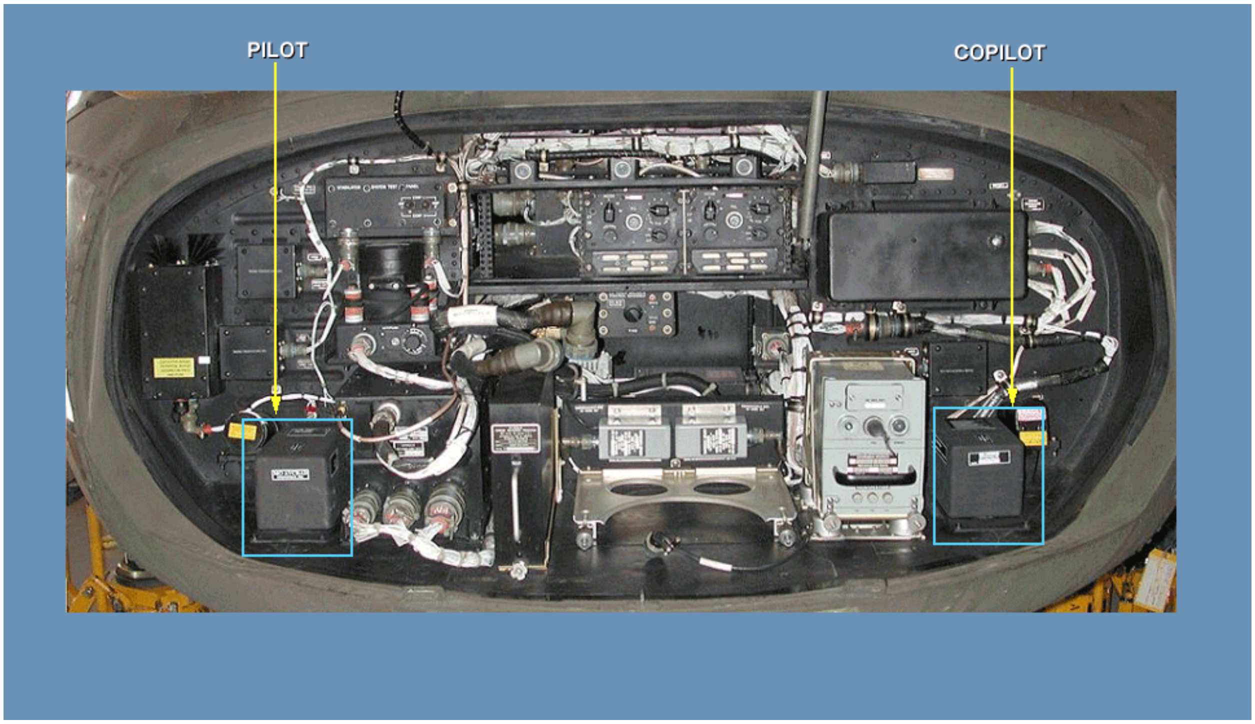


(1) Directional Gyro

(a) The ASN-43 directional gyro is located in the nose electronic compartment and produces a heading signal.

(2) Vertical Gyros

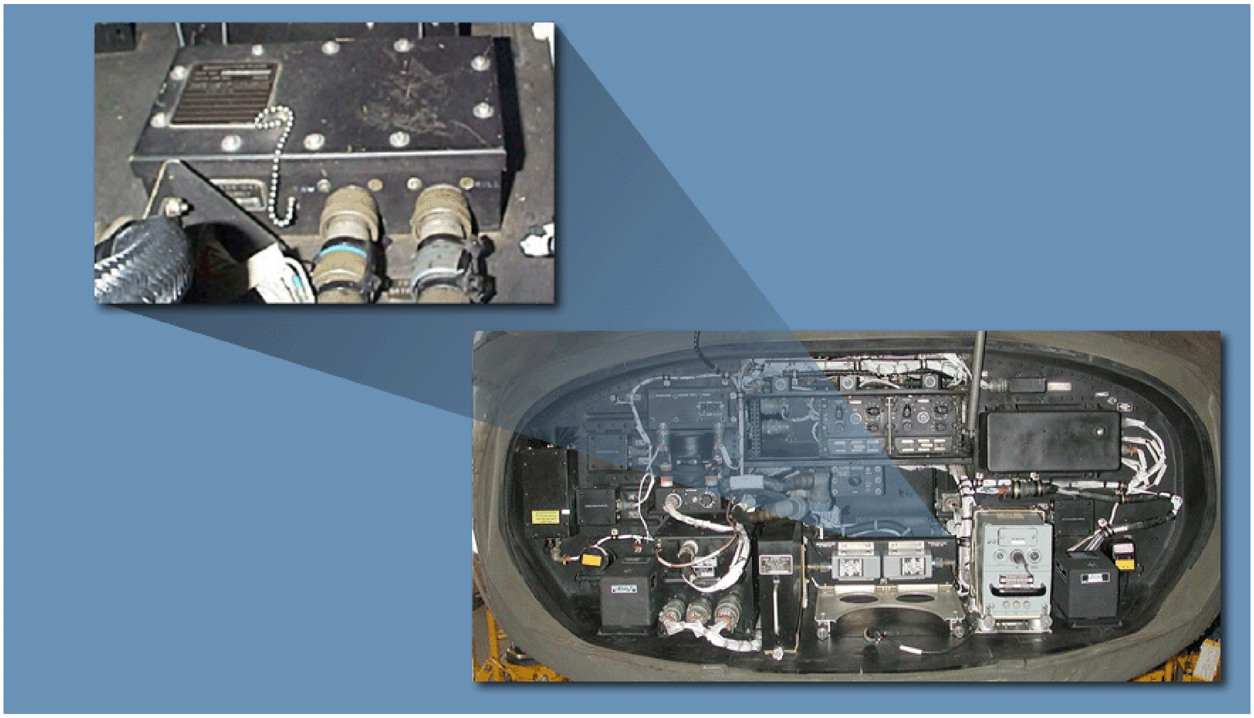
Frame #1110 (Vertical Gyros)



(a) Two vertical gyros, located in the nose electronic compartment, produce attitude signals indicating amount of movement for pitch and roll.

(3) Rate Gyro Assembly

Frame #1115 (Rate Gyro Assembly)

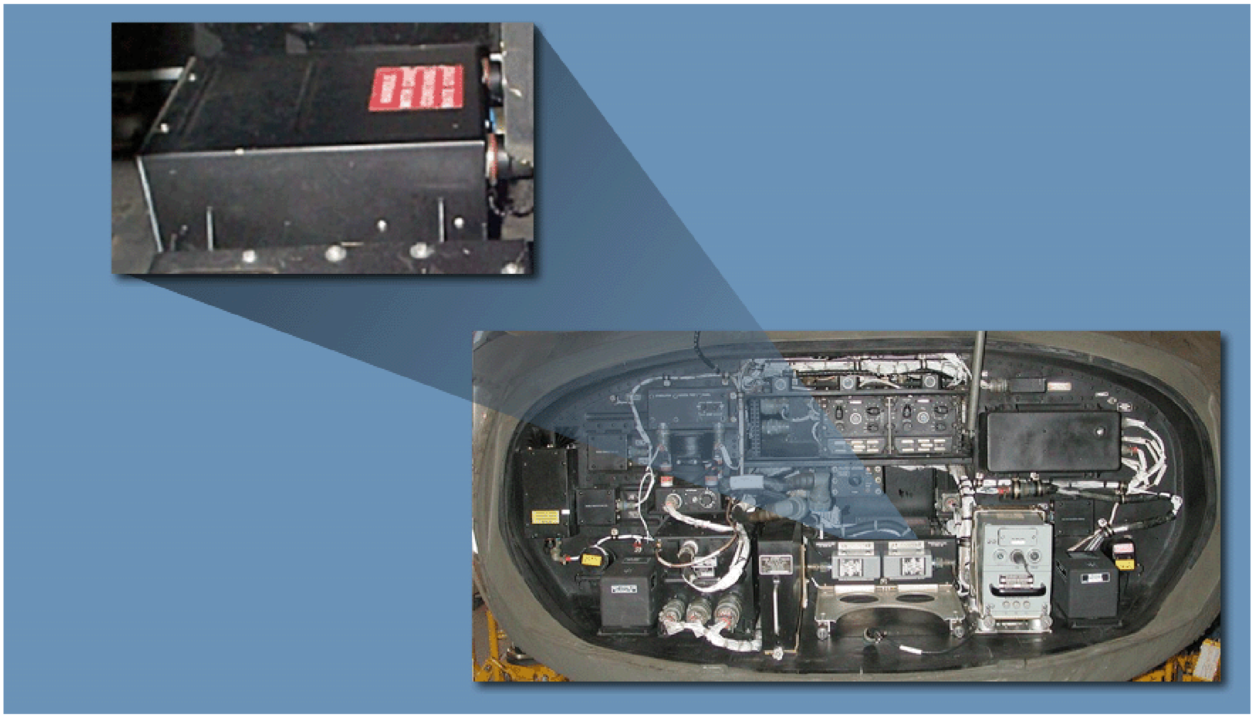


(a) The rate gyro assembly contains on yaw rate gyro and one roll rate gyro.

(b) The rate gyros produce a signal which indicates speed of movement.

(4) SAS Amplifier

Frame #1120 (SAS Amplifier)

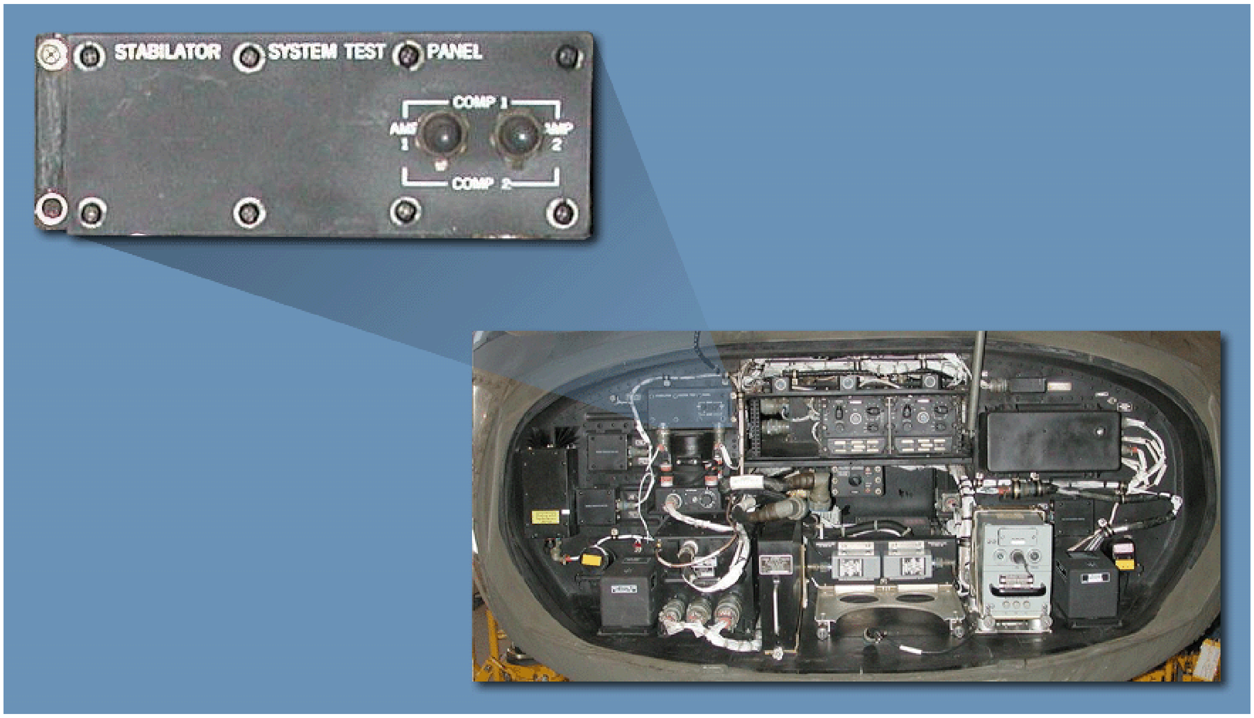


(a) The SAS amplifier processes sensor signals from the stabilator system, attitude indicating system, and contains an internal yaw rate gyro for deriving SAS actuator control signals.

(b) It is also part of the analog stability augmentation system, identified as SAS 1.

(5) Stabilator System Test Panel

Frame #1130 (Stabilator System Test Panel)



(a) On helicopters modified by MWO 55-1520-237-50-42, the stabilator test panel provides an additional check of the automatic mode disengagement for actuator position error.

(b) The test panel has two switches, spring loaded to the center position, marked AMP 1 and AMP 2.

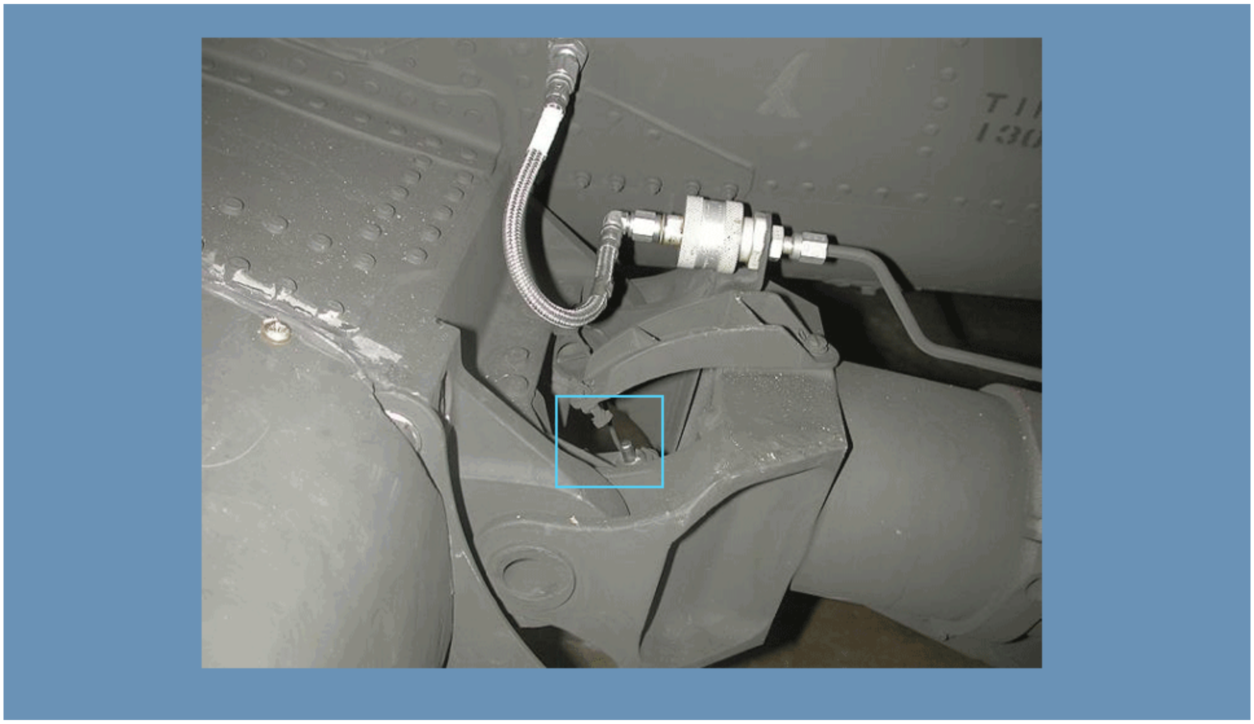
(c) The checks for No. 1 and No. 2 stabilator amplifiers are identical; only the No. 1 will be described.

(d) When the AMP 1 is momentarily placed in either COMP 1 or COMP 2 position, a simulated actuator position error signal is applied to the No. 1 amplifier.

(e) Since no input is applied to the No. 2 amplifier, a position error is detected by the No. 1 amplifier fault circuit and the automatic mode is disengaged.

(6) Drag Beam Weight On Wheels Switch

Frame #1135 (Drag Beam Weight On Wheels Switch)



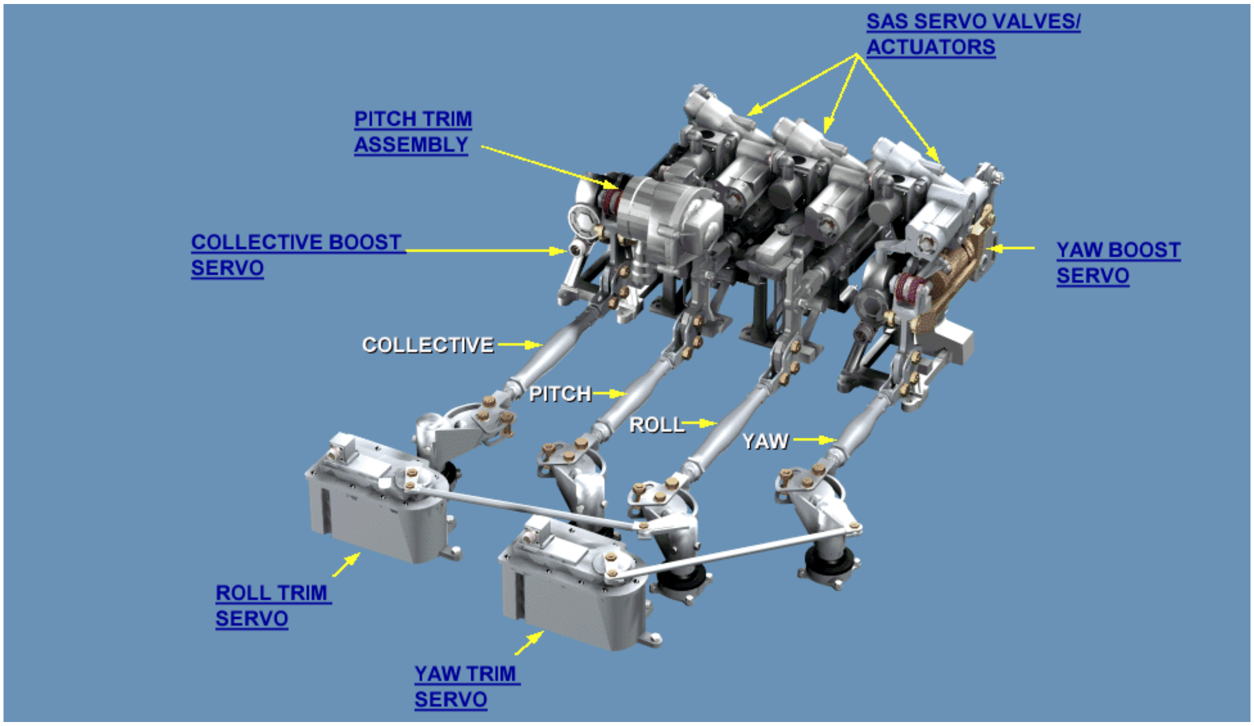
(a) The left side weight on wheel switch controls the application of a ground to K46 on the left hand relay panel.

(b) The left hand relay panel then enables the self-test feature on the SAS/FPS computer.

(c) The ground is removed with weight off the wheels (in-flight), assuring normal computer operation in the event that the test switch on the SAS/FPS computer is not placed to NORM.

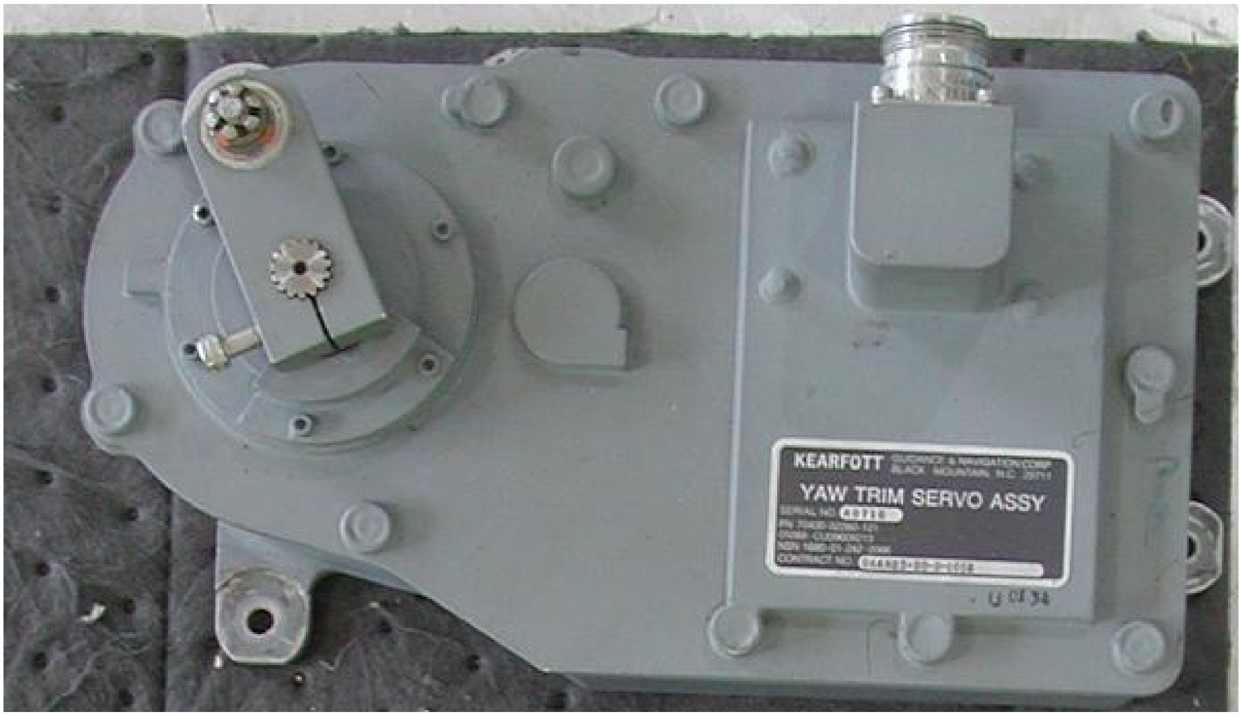
(7) Transmission/Upper Deck

Frame #1140 (Transmission/Upper Deck)



(a) YAW Trim Servo

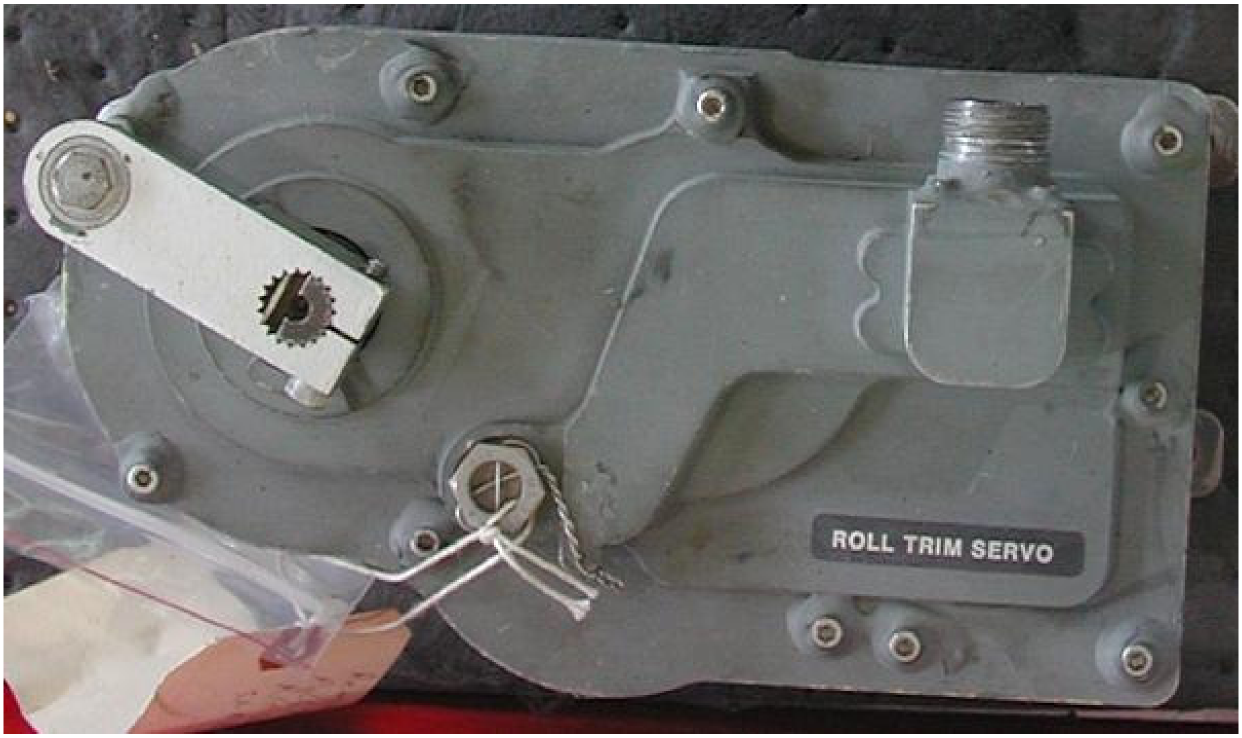
Frame #1152 (YAW Trim Servo)



1) The yaw trim servo is an electromechanical actuator installed in the yaw flight controls.

(b) ROLL Trim Servo

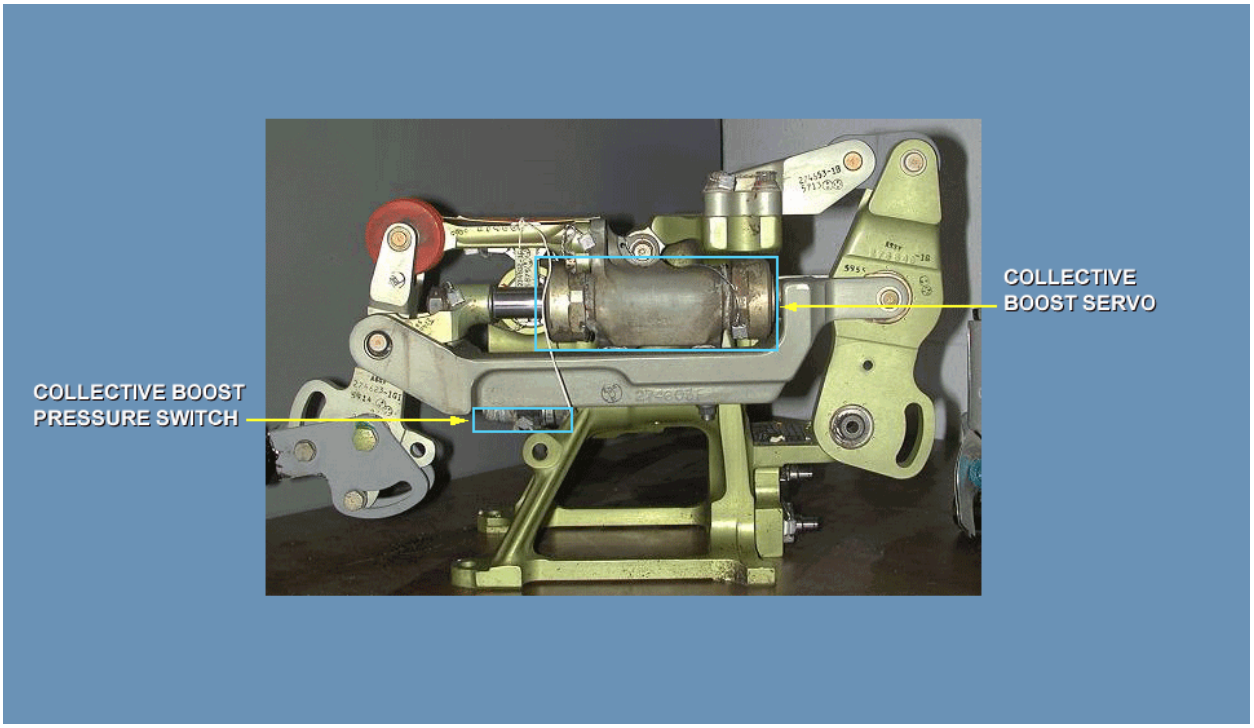
Frame #1150 (ROLL Trim Servo)



1) The roll trim servo is an electromechanical actuator installed in the roll flight controls.

(c) Collective Boost Servo

Frame #1165 (Collective Boost Servo/Pressure Switch)



1) The collective boost servo reduces stick and flight control friction.

2) The servo is controlled by a button marked BOOST on the Stabilator Control/AUTO FLIGHT CONTROL panel.

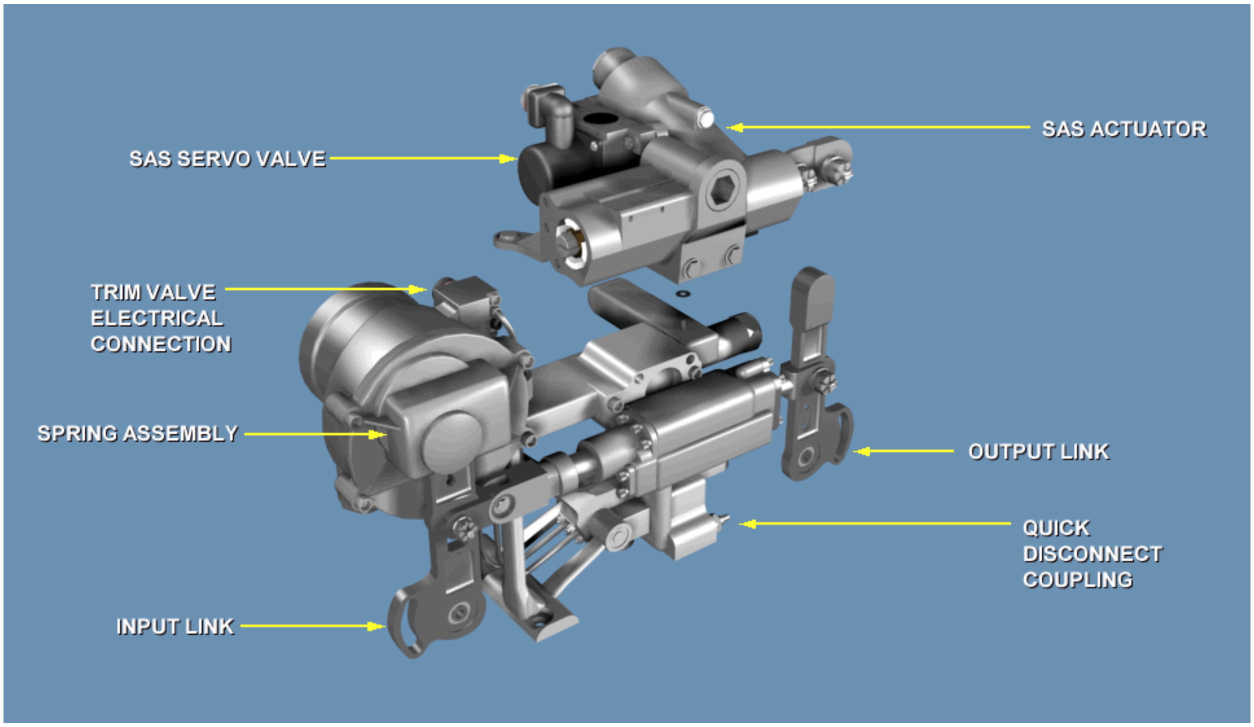
3) The collective boost pressure switch turns on the BOOST SERVO OFF capsule on the caution/advisory panel, when hydraulic pressure is removed.

4) The collective boost servo has a jam simulation button.

5) When pressed, the button displaces the spool valve sleeve and causes the BOOST SERVO OFF capsule on the caution/advisory panel to go on.

(d) Pitch Trim Assembly

Frame #1162 (Pitch Trim Assembly Breakdown)



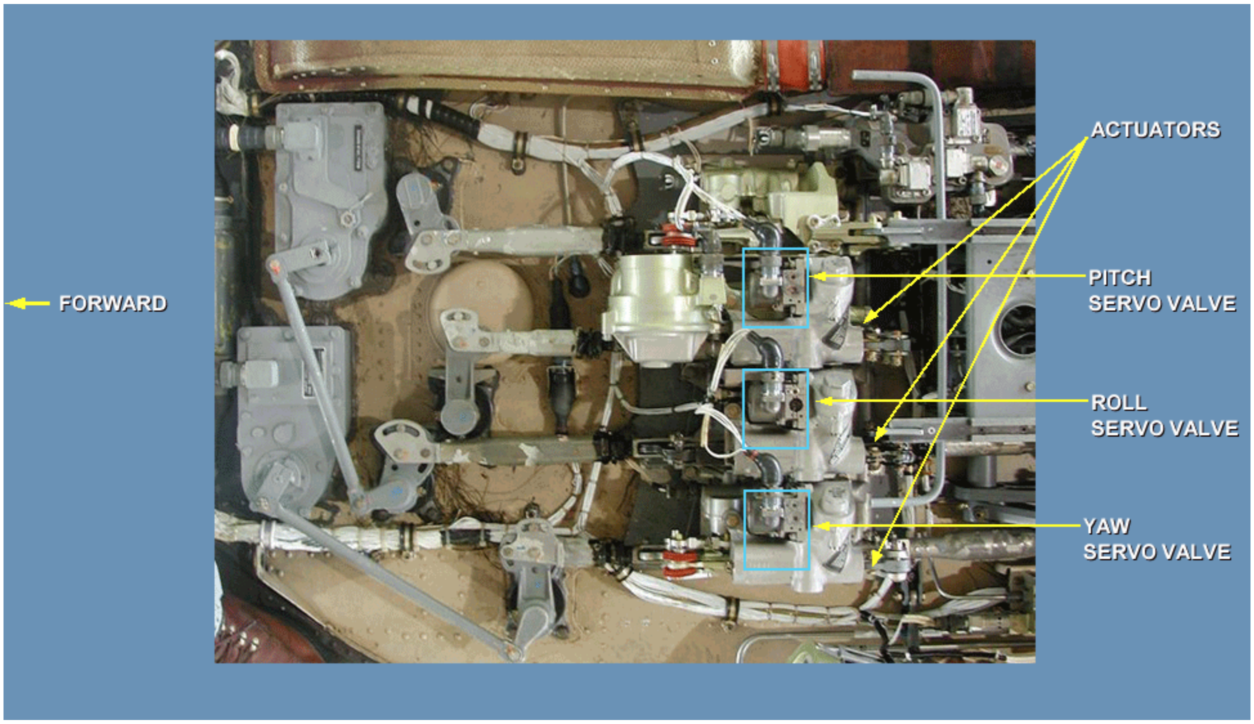
1) The pitch/trim assembly controls the longitudinal axis and the attitude of the helicopter.

2) The actuator is controlled by the SAS1, SAS2, TRIM and FPS buttons on the Stabilator Control/AUTO FLIGHT CONTROL panel.

3) TRIM maintains a position of the cyclic stick in the longitudinal axis.

(e) SAS Servo Valves/Actuators

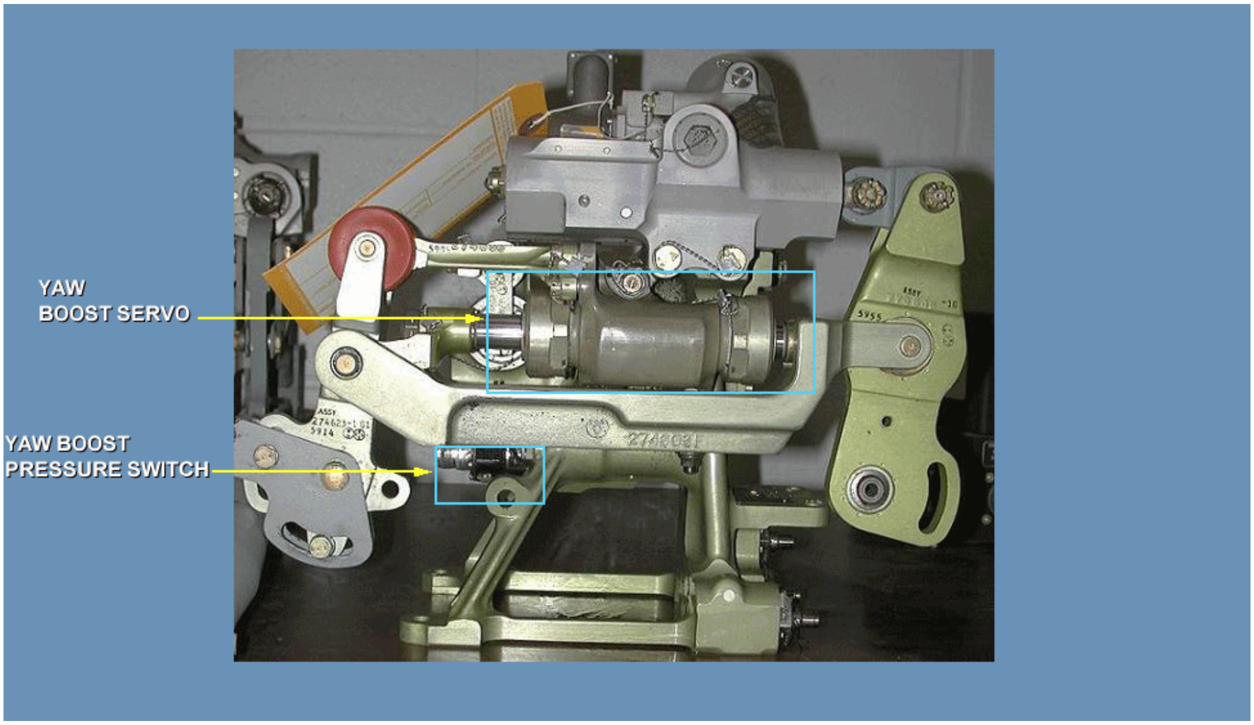
Frame #1155 (SAS Servo Valves/Actuators)



1) The SAS servo valve/actuators (pilot-assist servo assemblies) reduce pilot work load by providing control boost, stick trimming, stability augmentation, and control inputs from the AFCS.

(f) YAW Boost Servo

Frame #1170 (YAW Boost Servo/Pressure Switch)



1) The yaw boost servo reduces stick and flight control friction.

2) The yaw boost servo is the same as the collective boost, except for the addition of a SAS actuator, which provides rate damping.

3) The servo is controlled by a button marked BOOST, on the Stabilator Control/AUTO FLIGHT CONTROL panel.

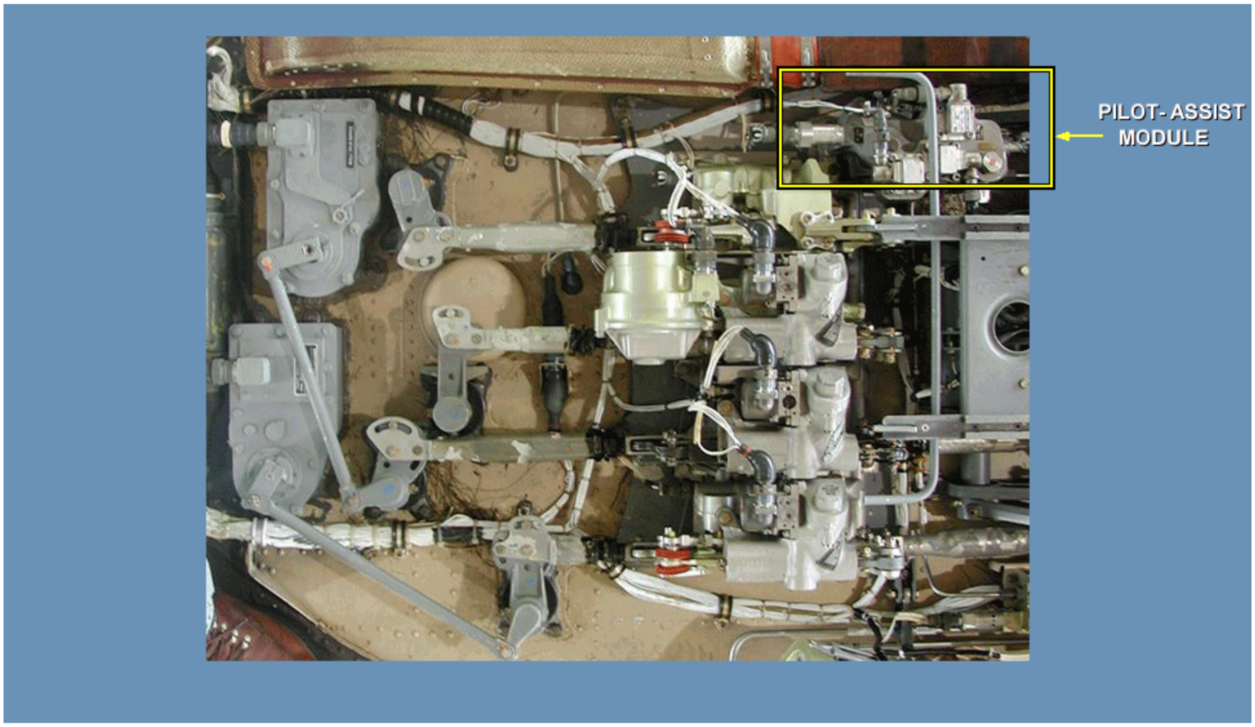
4) The yaw boost pressure switch turns on the BOOST SERVO OFF capsule on the caution/advisory panel, when hydraulic pressure is removed.

5) The yaw boost servo has a jam simulation button.

6) When pressed, the button displaces the spool valve sleeve and causes the BOOST SERVO OFF capsule on the caution/advisory panel to go on.

(8) Pilot-Assist Module

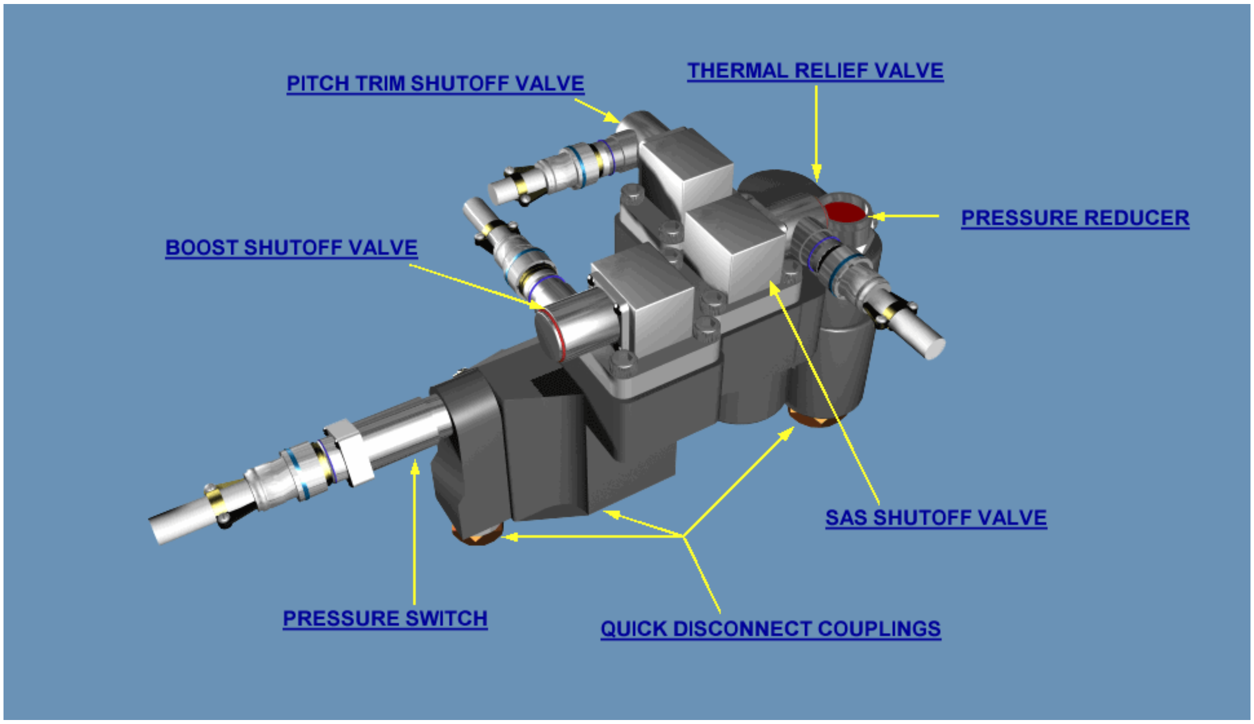
Frame #1145 (Pilot-Assist Module)



(a) The pilot-assist module supplies hydraulic pressure to the pilot-assist servos (collective boost, yaw boost, yaw SAS actuator, roll SAS actuator, pitch SAS actuator, pitch/trim).

(b) Pilot-Assist Module Detailed

Frame #1147 (Pilot-Assist Module Detailed)



1) The pilot-assist module consists of a thermal relief valve, a pressure reducer, a SAS shutoff valve, a boost shutoff valve, a pitch/trim turn-on valve, a pressure switch, and self-sealing quick-disconnect couplings.

a) Thermal Relief Valve

1 The thermal relief valve protects the module from damage due to thermal expansion of hydraulic fluid kept in the module during storage.

2 The thermal relief valve has no function when the module is installed on the helicopter.

b) Pressure Reducer

1 The pressure reducer reduces system hydraulic pressure from 3000 to 1000 psi for pitch/trim servo operation.

2 It has a relief valve built into it to protect the pitch/trim servo from adverse system pressure.

3 If the pressure reducer fails, the relief valve goes into bypass, and a visual indicator, on the pressure reducer, pops.

4 The indicator will remain visible until manually reset.

c) SAS Shutoff

1 The SAS shutoff valve turns off the hydraulic system pressure to the SAS actuators.

d) Quick Disconnect Couplings

1 The module also has self-sealing, quick-disconnect couplings on all input and output ports, for ease of maintenance.

e) Pressure Switch

1 The pressure switch on the module turns on the SAS OFF light on the caution/advisory panel when the hydraulic pressure drops below limits.

f) Boost Shutoff Valve

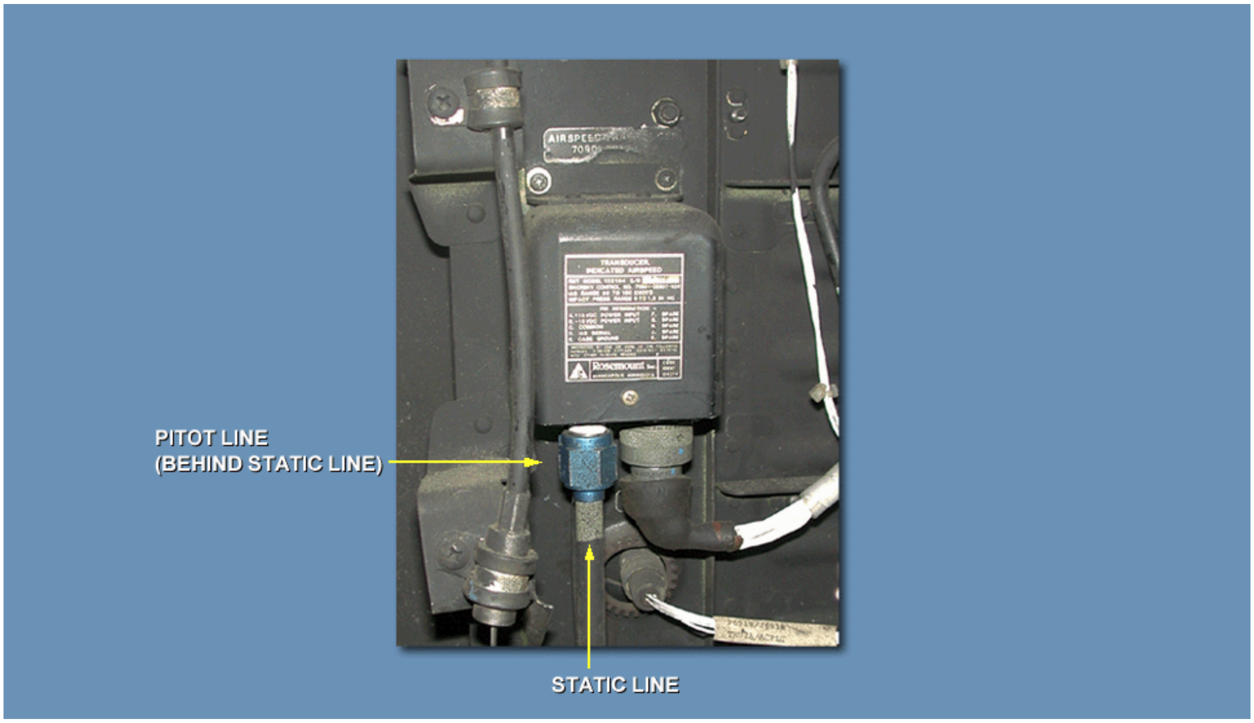
1 The boost shutoff valve turns off the hydraulic system pressure to the collective and yaw boost servos.

g) Pitch Trim Shutoff Valve

1 The pitch/trim shutoff valve controls the hydraulic system pressure to the pitch trim servo.

(9) Airspeed Transducer

Frame #1175 (Airspeed Transducer)

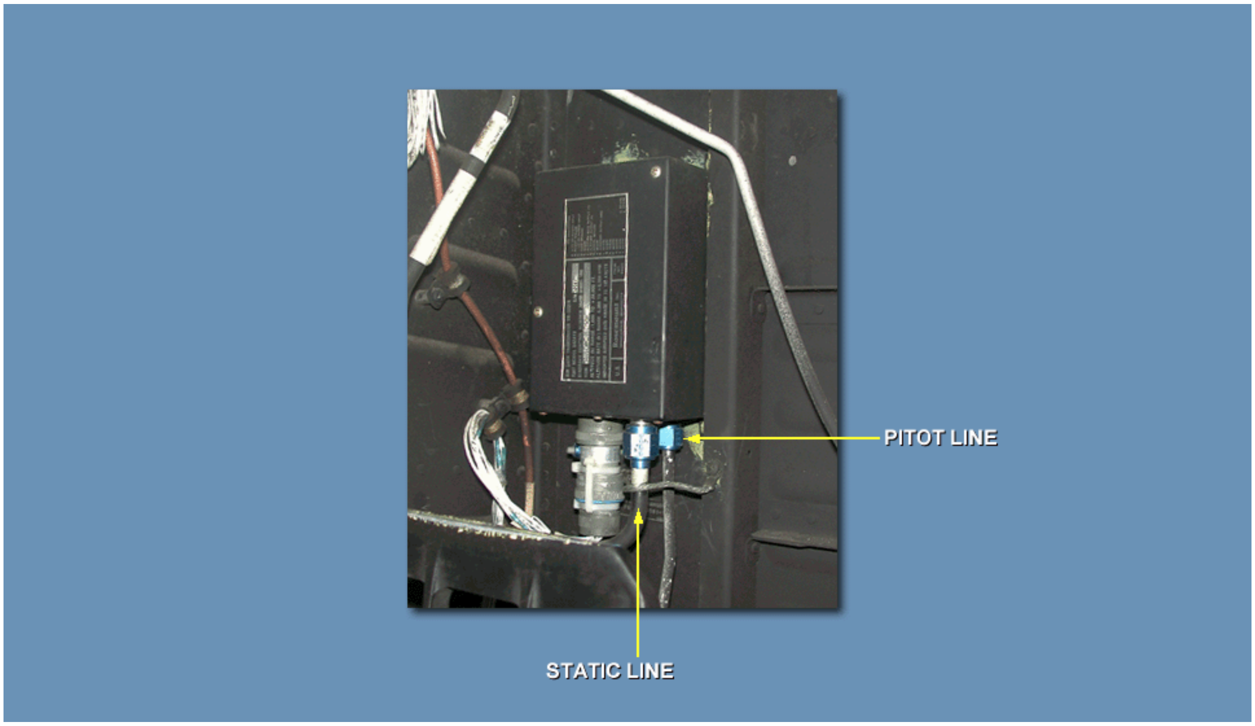


(a) The airspeed transducer is located on the bulkhead forward of the copilot pedals.

(b) The transducer receives 15 V dc excitation voltage from the No. 1 stabilator amplifier and produces a positive V dc signal that represents helicopter forward airspeed.

(10) Air Data Transducer

Frame #1180 (Air Data Transducer)



(a) The air data transducer is located on the bulkhead forward of the pilot pedals.

(b) The transducer produces a positive V dc signal that represents helicopter forward airspeed.

(c) It receives 15 V dc excitation voltage from the No. 1 stabilator amplifier.

(11) Stabilator Indicators

Frame #1185 (Stabilator Indicators)

(a) A stabilator indicator is located on each side of the instrument panel, giving the pilots a remote indication of stabilator position.

(b) They receive 26 V ac from the AC essential bus through a circuit breaker marked STAB IND, and receive a synchro signal from the stabilator position transmitter.

(c) If electrical power is removed from the indicators, the indicator pointers will disappear from view and OFF Flags will appear.

(d) The copilot indicator may vary from the pilot indicator as much as 2 degrees.

(e) The indicator is marked from 45 degrees down (DN) to 10 degrees up.

(12) Caution/Advisory Panel

Frame #1190 (Caution/Advisory Panel)

(a) The caution panel contains warning capsules that indicate the status of the Boost Servo, Stabilator, SAS, Trim and Flight Path Stabilization portions of AFCS.

1) BOOST SERVO OFF

a) When the BOOST SERVO OFF capsule is illuminated, it indicates loss of second stage hydraulic pressure to the boost servo, or a boost servo jam.

2) STABILATOR

a) When the STABILATOR capsule is illuminated, it indicates the system is on, but is in the manual mode.

3) SAS OFF

a) When the SAS OFF capsule is illuminated, it indicates hydraulic pressure to the SAS actuator is below minimum.

4) TRIM FAIL

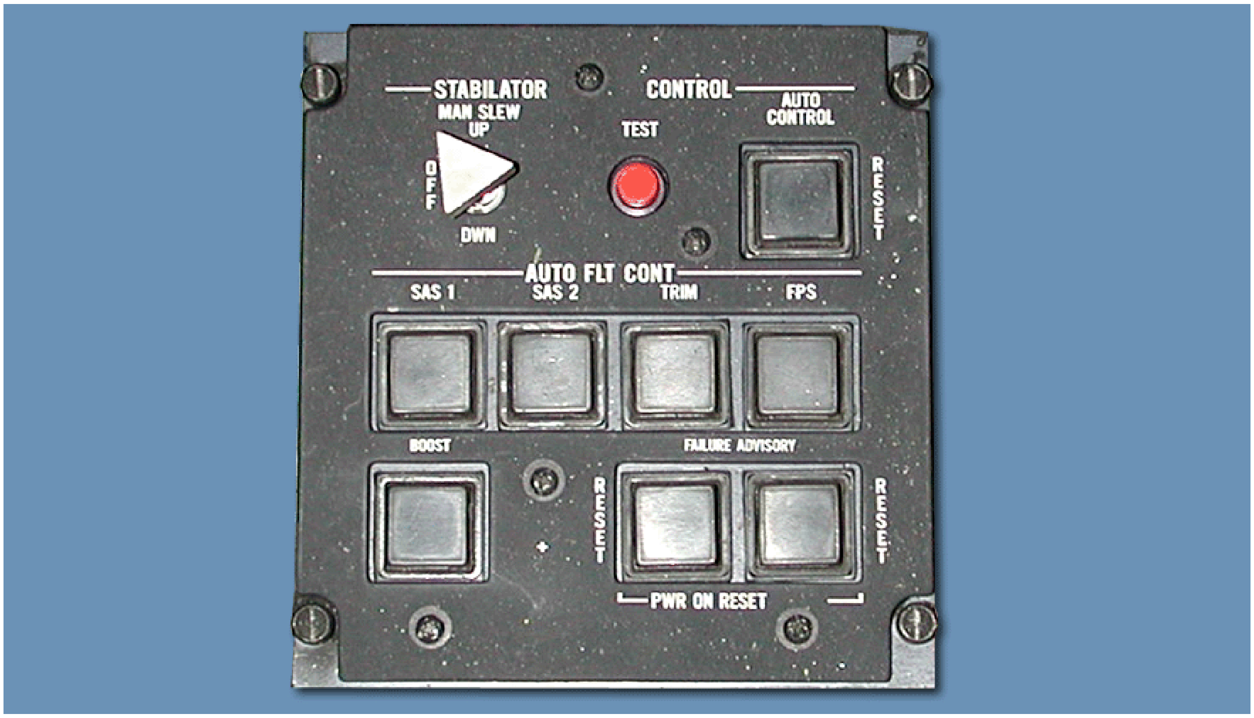
a) When the TRIM FAIL capsule illuminates, it indicates that yaw, roll, or pitch trim actuators are not responding accurately to computer signals.

5) FLT PATH STAB

a) When the FLT PATH STAB capsule illuminates, it indicates that FPS is inoperative in one or more axis.

(13) Stabilator Control/Auto Flight Control Panel

Frame #1195 (Stabilator Control/Auto Flight Control Panel)



(a) The stabilator control portion of the AFCS control panel provides for manual stabilator control, re-engagement of the automatic mode, and a self-test of the stabilator system.

(b) The automatic mode will allow the stabilator to be automatically operated from about 39 degrees trailing edge down to 9 degrees trailing edge up.

(c) Manual operation is also restricted to these limits.

(d) STABILATOR MAN SLEW

1) The MANUAL SLEW switch lets the pilot control stabilator position.

2) When positioned either UP or DWN, the automatic mode of operation cannot be engaged even if no failure is present.

3) The slew-up switch mounted on the cyclic sticks, operate exactly as the MAN SLEW switch, except only in the up direction.

(e) TEST

1) The TEST switch is used to check the AUTO mode feature and is inoperative above 60 KIAS.

2) When the test button is depressed, the #1 stabilator actuator begins to move.

3) Once the allowable miss-compare signal is reached, the automatic mode of operation is deactivated and control of the stabilator should go to the manual mode.

4) The maximum miss-compare range is 10 degrees at airspeeds up to 30 KIAS and tapers to 4 degrees at 150 KIAS.

(f) AUTO CONTROL/Reset Switch

1) When initial power is applied to the stabilator system, it will be in the automatic mode.

2) If a malfunction occurs in the automatic mode, the system will switch to manual, ON will go off in the AUTO CONTROL window, and the STABILATOR caution and MASTER CAUTION lights will go on and a beeping tone will be heard in the pilot's headphones.

3) It may be possible to regain the auto mode by pressing the AUTO CONTROL RESET.

4) If the automatic mode is regained, ON will appear in the AUTO CONTROL switch window and the caution lights will go off.

5) The stabilator auto mode is held in the energized state within the stabilator control amplifier.

6) On certain occasions during interruption of dc power, such as switching of generators, it is possible to have conditions where the stabilator automatic mode may shut down.

7) If the automatic mode shuts down during flight because of an ac power failure, the helicopter shall be slowed to 80 KIAS before power is restored.

8) In this case, the AUTO CONTROL RESET switch may be pressed to reengage the auto mode.

9) If the automatic mode is not regained, the MASTER CAUTION must be reset, which turns off the beeping tone, and the stabilator is controlled throughout its range with the MANUAL SLEW switch.

(g) SAS 1

1) When the SAS 1 switch is depressed, it engages SAS 1.

(h) SAS 2

1) When the SAS 2 switch is depressed, it engages SAS 2.

(i) TRIM

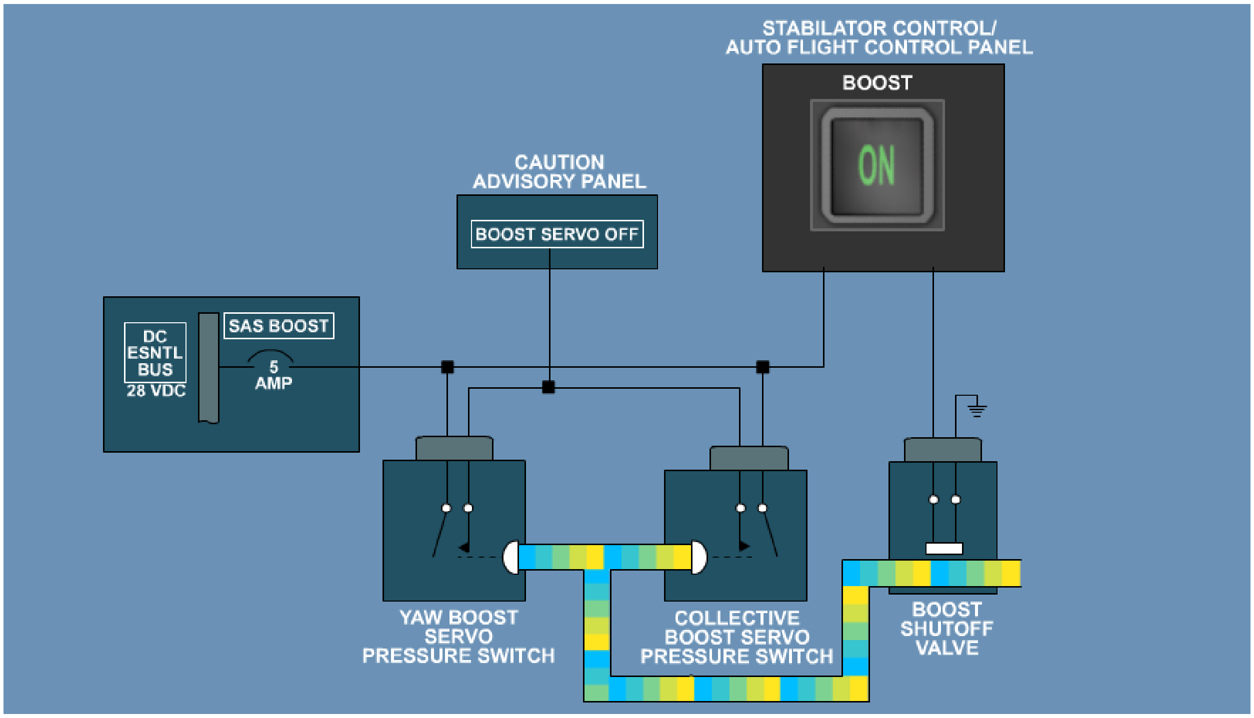
1) When the trim switch is depressed, it engages Trim.

(j) FPS

1) When the FPS switch is depressed, it engages FPS.

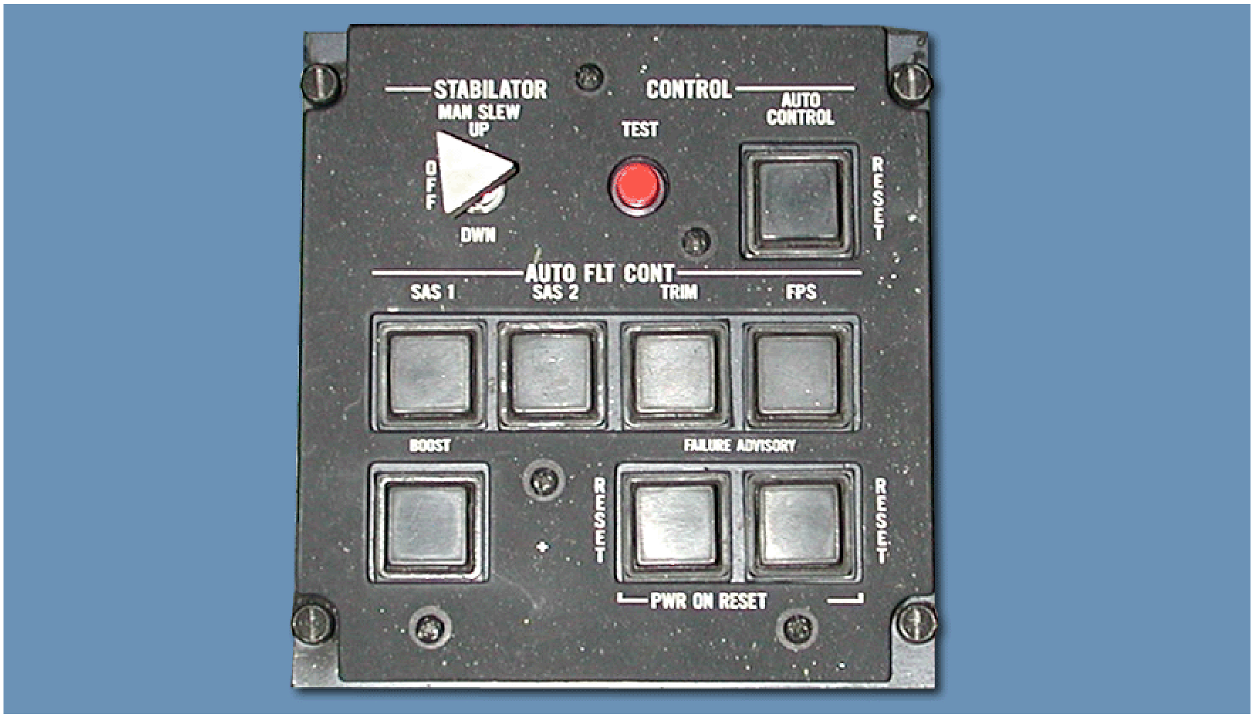
(k) BOOST

Frame #1197 (Boost Switch FLASH)



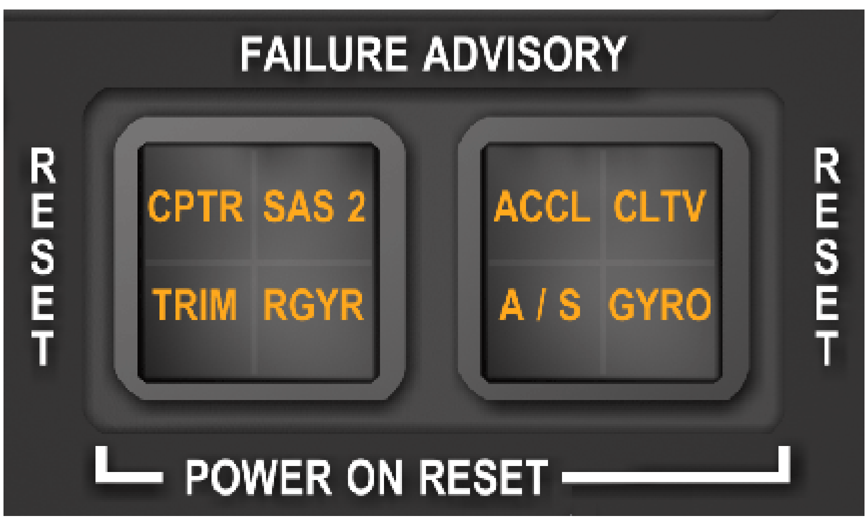
1) When the BOOST switch is depressed it engages BOOST.

Frame #1195 (Stabilator Control/Autoflight Control Panel)



(l) FAILURE ADVISORY

Frame #1198 (Failure Advisory/Reset)



1) Failure Advisory lights give the following possible indications:

a) CPTR

1 SAS/FPS computer failed

2 Pitch trim servo valve circuit open

3 Pitch, roll or yaw SAS actuator valve circuit open.

b) TRIM

1 Pitch trim servo coil short circuit

2 Pitch, roll or yaw trim actuator failed

3 Roll stick force changing too fast

4 Pedal force changing too fast.

c) RGYR

1 Pitch, roll or yaw rate gyro failed.

d) SAS 2

1 Pitch, roll or yaw SAS actuator valve coil failed

2 Pitch, roll or yaw rate gyro failed.

e) ACCL

1 NO. 1 or NO. 2 Lateral Accelerometer Failed.

f) A/S

1 Airspeed or air data transducer failed.

g) CLTV

1 NO. 1 or NO. 2 Collective stick transducer failed.

2 Could be affected by stabilator system failure

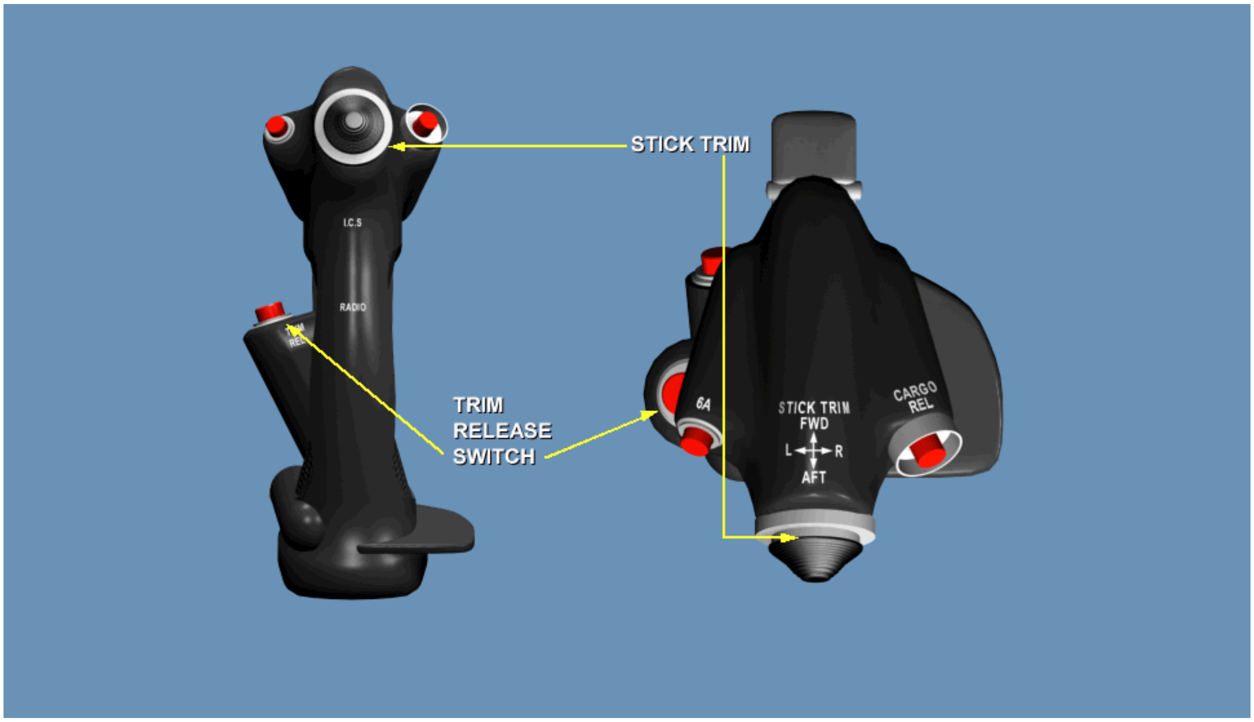
3 Wiring failures can cause any failure indication

h) GYRO

1 NO. 1 or NO. 2 vertical gyro or compass system failed.

(14) Cyclic Stick Grip

Frame #1200 (Cyclic Stick Grip)



(a) The TRIM RELEASE switch, when pressed, allow the pilot or copilot to fly the helicopter with light stick forces.

(b) The STICK TRIM switch allows the pilot or copilot to make minor changes to the pitch and roll attitude cyclic stick reference position when FPS and TRIM is engaged.

(15) Stabilator Slew Switch

Frame #1205 (Stabilator Slew Switch)

(a) A pull-type stabilator slew up switch is installed on each cyclic stick below the grip.

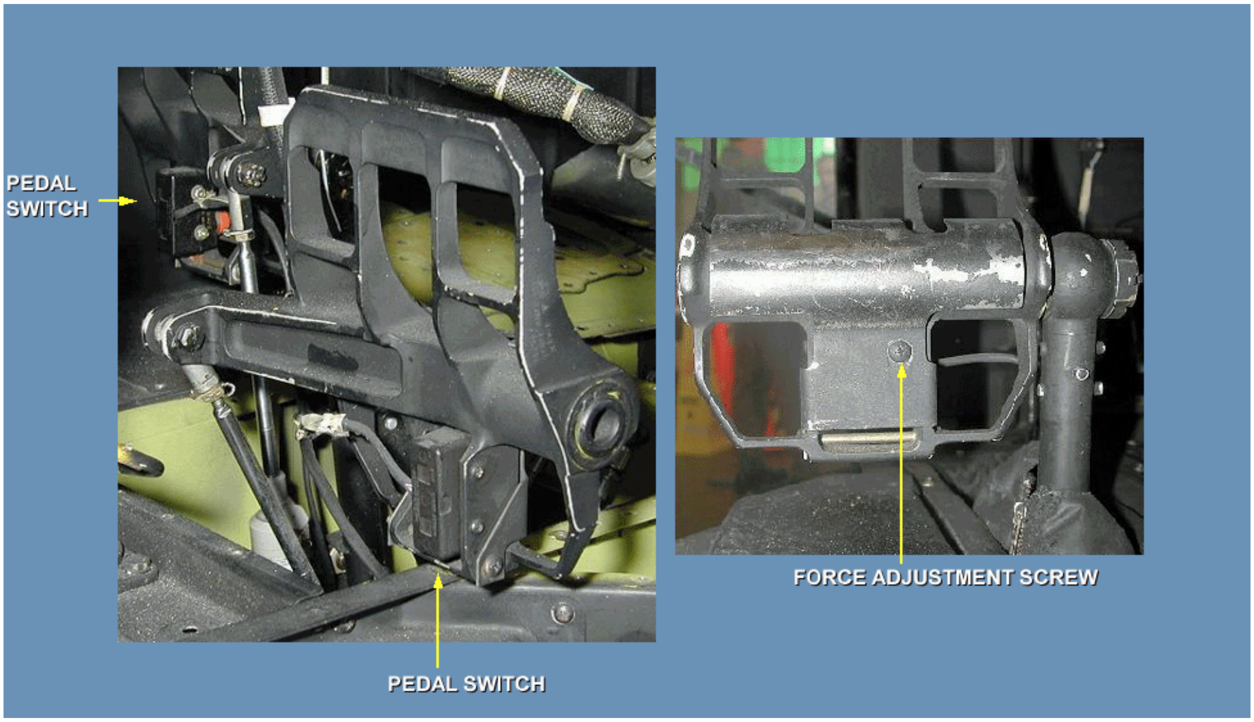
(b) The switch provides the pilots with rapid accessibility to stabilator slew up.

(c) The cyclic slew switch is wired in parallel with the stabilator panel MAN SLEW-UP switch position only.

(d) When the switch is activated, the stabilator trailing edge will begin to move up and continue until the up limit stop is reached or the switch is released.

(16) Pedal Switches

Frame #1210 (Pedal Switches)



(a) At airspeeds below 60 knots, the pedal switches provide a momentary release of yaw trim to allow a new heading reference to be established.

(b) Above 60 knots the pedal switches and the TRIM REL switch together provide yaw trim release.

(c) With trim engaged, the normally closed pedal switches apply a +28 V dc signal to the SAS/FPS computer.

(d) The computer maintains yaw trim by engaging the clutch in the yaw trim actuator.

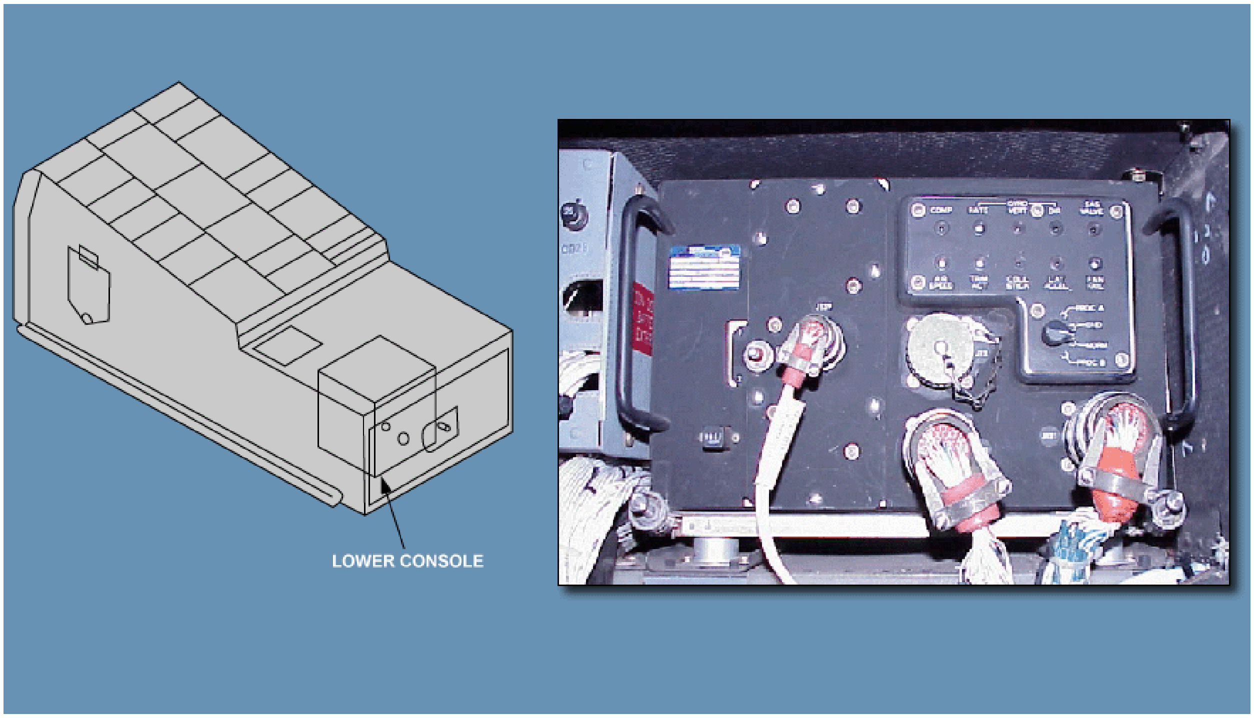
(e) The pedal switches are actuated by a force of 1 to 5 lbs, when the pilot's feet are placed on the pedals.

(f) This opens the voltage path to the computer, which then disengages the clutch in the yaw trim actuator.

(g) The clutch disengages the flight control linkage, permitting unrestricted pedal movement.

(17) SAS 2/FPS Computer

Frame #1215 (SAS 2/FPS Computer)



(a) The SAS/FPS computer controls all digital AFCS functions and flight control functions, including digital Stability Augmentation System (SAS 2), Flight Path Stabilization (FPS), and cyclic and pedal trim.

(b) The computer continuously monitors the operation of all flight functions, and automatically disables any function in case of failure.

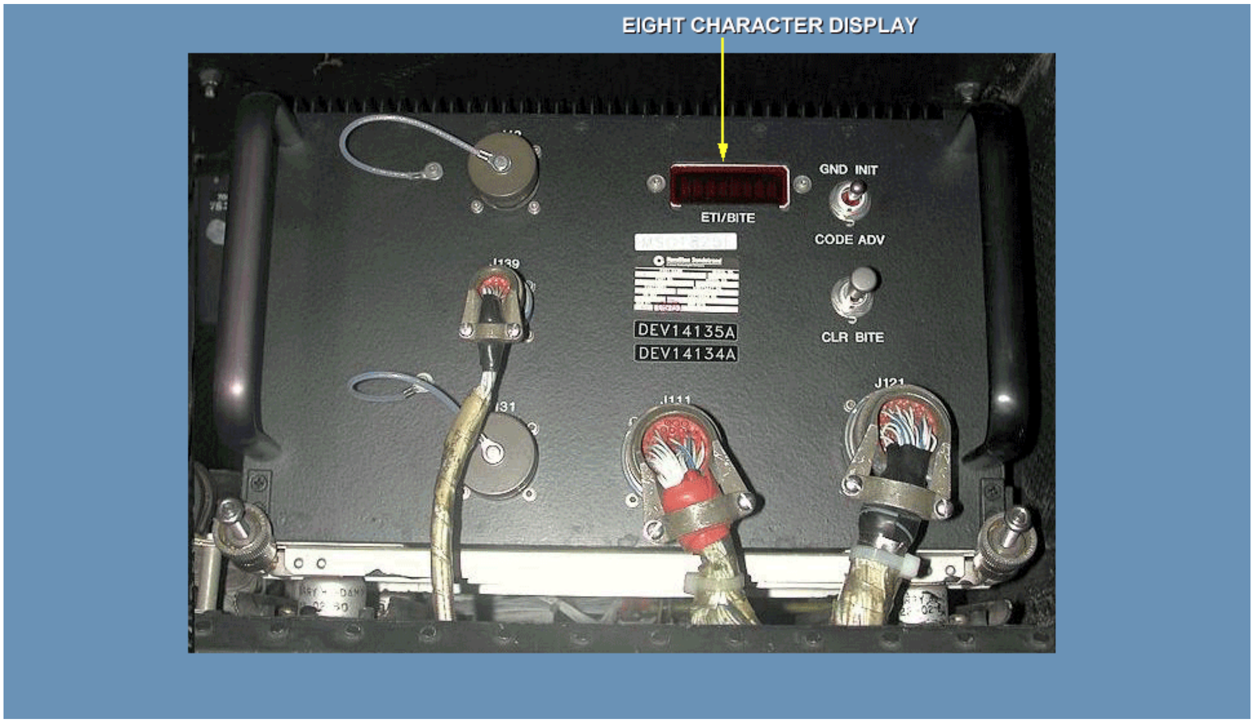
(c) The maintenance indicators on the front panel, change from black to white to identify the source of malfunction.

(d) The computer front panel also contains a rotary switch for computer self-test checkout.

(e) It contains four individual cards used for SAS 2, FPS, TRIM, and Fault Monitoring.

(18) Advanced Flight Control Computer (AFCC)

Frame #1216 (Advanced Flight Control Computer) (AFCC)



(a) The ADVANCED FLIGHT CONTROL COMPUTER (AFCC) is a modernized replacement for the SAS/FPS flight computer.

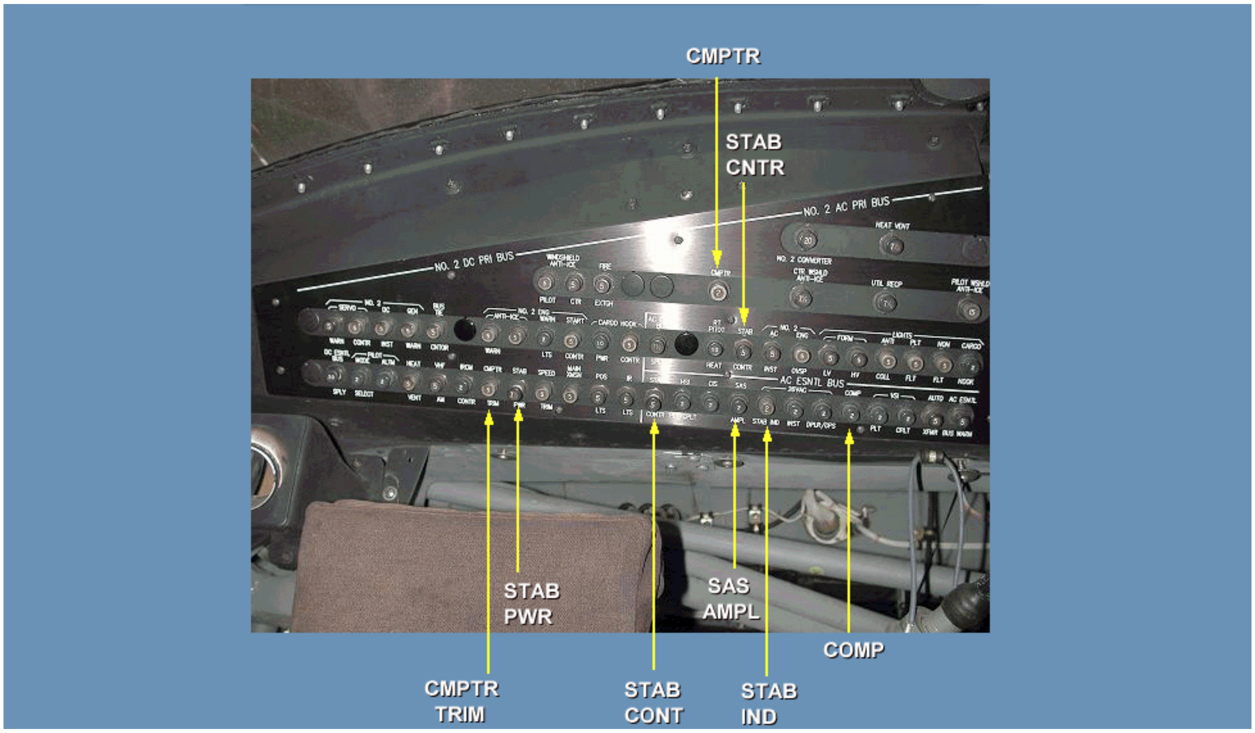
(b) It is operationally the same as its predecessor, but includes extensive self and system diagnostic capabilities that facilitate maintenance of the AFCS system of which it is part.

(c) The AFCC displays status information, and when problems are detected, can be operated to produce specific error codes and system parameter values needed for troubleshooting and operational check.

(d) Additional information can be found in Change 4 to TM 11-1520-237-23 and, at https://www.uhpo.redstone.army.mil/reference/publications/tm/afcc/index.html.

(19) Pilot Circuit Breaker Panel

Frame #1220 (Pilot Circuit Breaker Panel)



(a) The pilot circuit breaker panel contains the No. 2 DC primary bus, the No. 2 AC primary bus, and the No. 2 AC, and No. 2 essential bus.

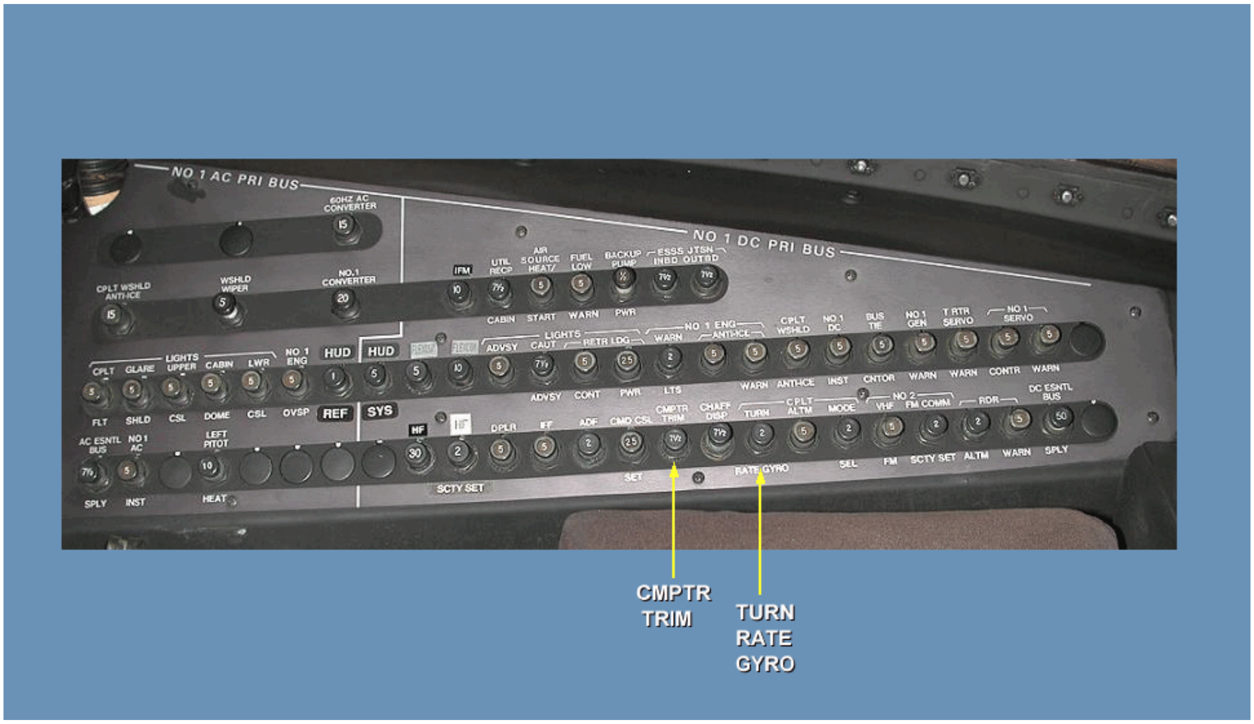
(20) Upper Console

Frame #1225 (Upper Console)

(a) The upper console contains the DC essential bus circuit breaker panels.

(21) Copilot Circuit Breaker Panel

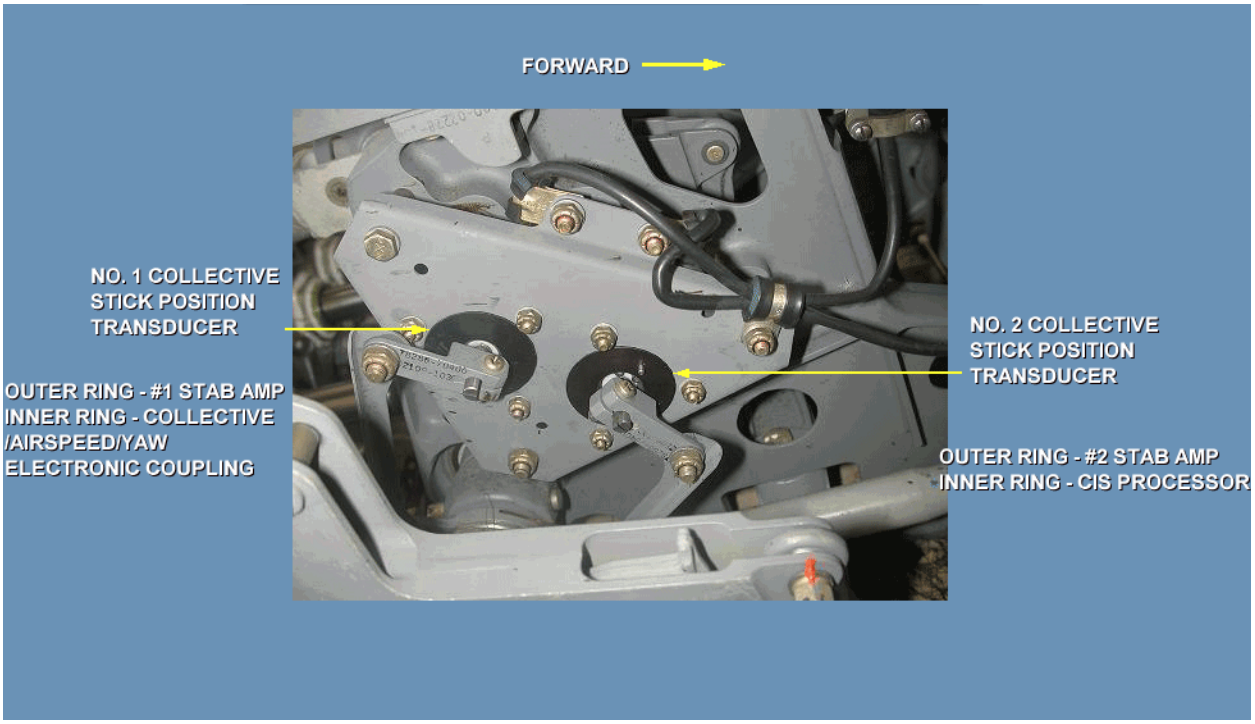
Frame #1230 (Copilot Circuit Breaker Panel)



(a) The copilot circuit breaker panel contains the No. 1 AC primary bus, the No. 1 DC primary bus and the No. 1 AC and No. 1 DC essential buses.

(22) Collective Stick Position Transducers

Frame #1235 (Collective Stick Position Transducers)



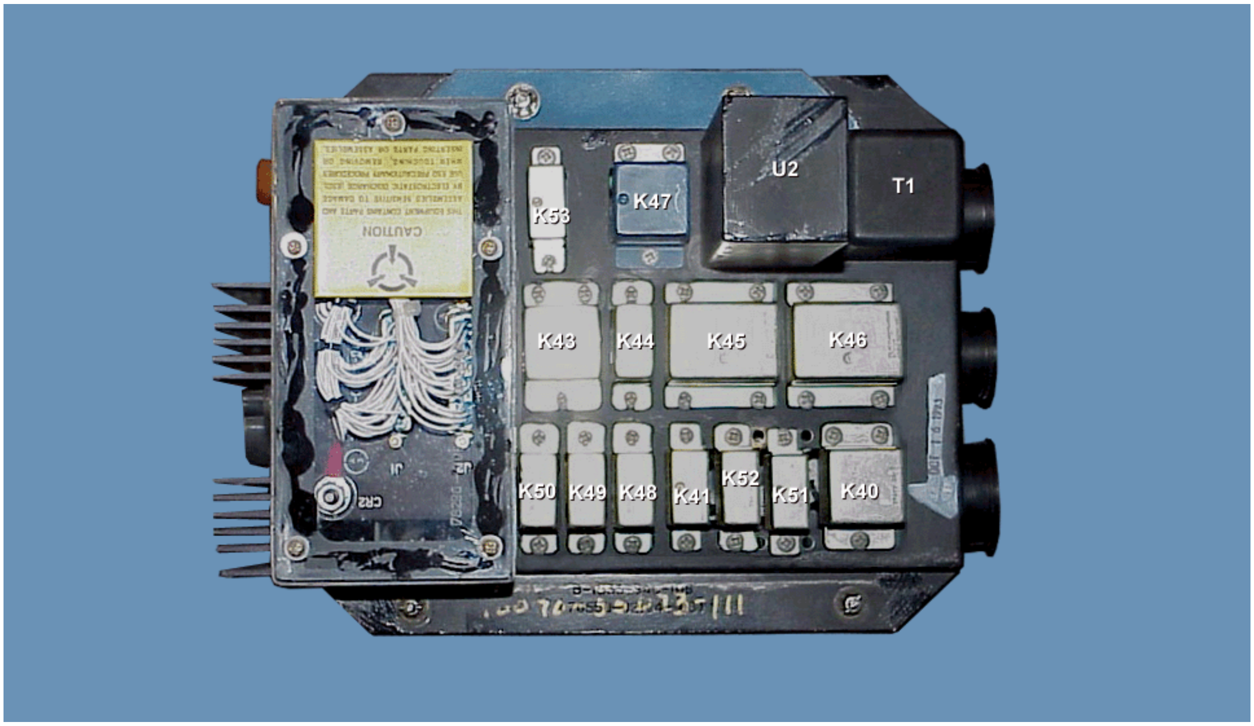
(a) The position transducers are located on the mixing unit.

(b) Both transducers receive 15 V dc excitation voltage from their respective stabilator amplifiers and are part of Stabilator AUTO MODE engage requirements.

(c) Variable dc output voltages represents collective stick position.

(23) Left Relay Panel

Frame #1240 (Left Relay Panel)



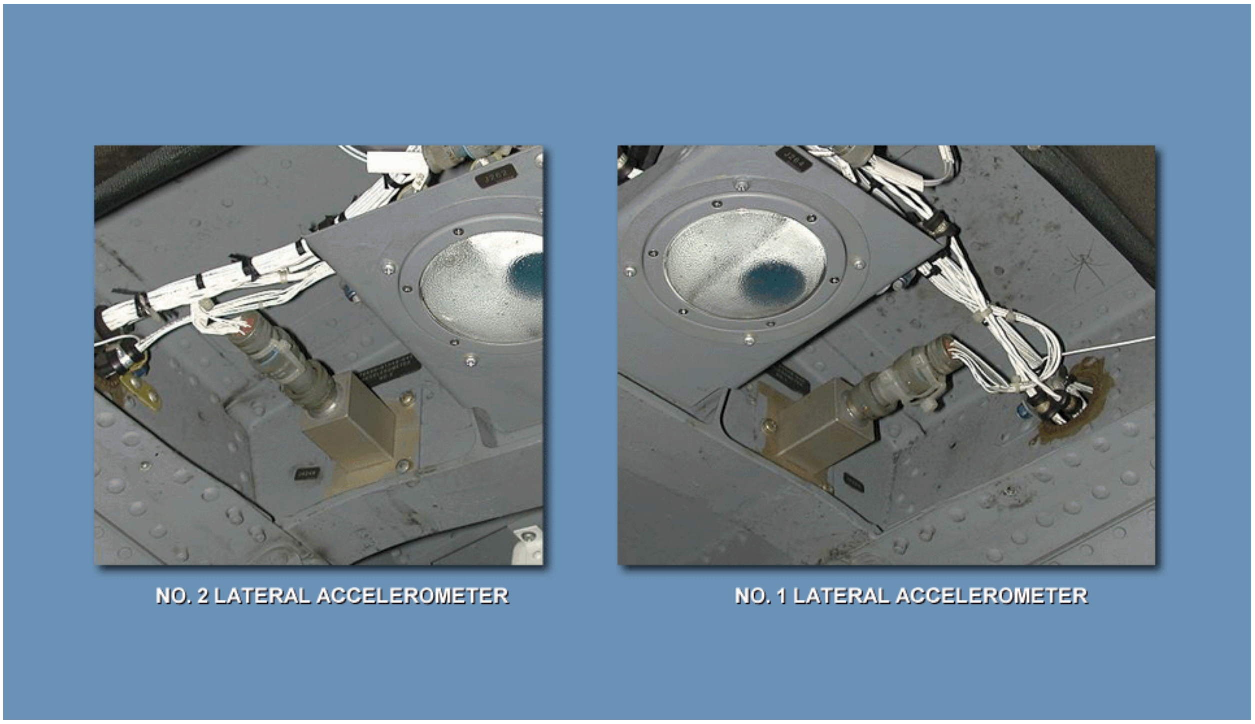
(a) The left side weight on wheel switch, controls the application of a ground to K46 on the left hand relay panel.

(b) The left hand relay panel then enables the self-test feature on the SAS/FPS computer.

(c) The ground is removed with weight off the wheels (inflight), assuring normal computer operation in the event that the test switch on the SAS/FPS computer is not placed to NORM.

(24) Lateral Accelerometer

Frame #1245 (Lateral Accelerometer)



(a) The lateral accelerometers are located in the cabin area overhead on the #1 and #2 sides of the aircraft.

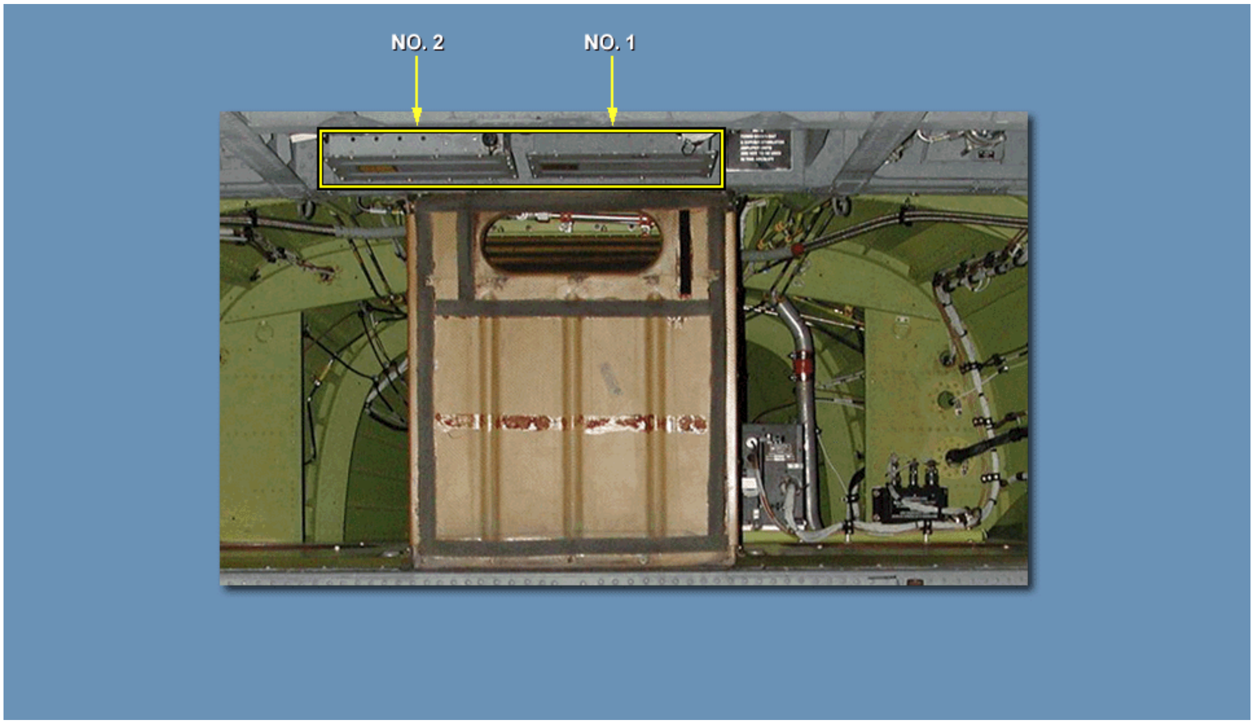
(b) The accelerometers receive 15 V dc excitation voltage from their respective stabilator amplifiers.

(c) Their unfiltered output voltage is based on an out of trim condition.

(d) Filtered output voltage is used by the stabilator amplifier for programming and to produce dc signals that represents side slips or skids in flight and bank angle on the ground.

(25) Stabilator Amplifier

Frame #1250 (Stabilator Amplifiers)



(a) The stabilator amplifiers are located on the center ceiling, in the rear cabin area.

(b) The stabilator amplifiers process airspeed, lateral acceleration, and collective stick position signals from the respective sensors and pitch rate signals from internal gyros, to derive stabilator actuator control signals.

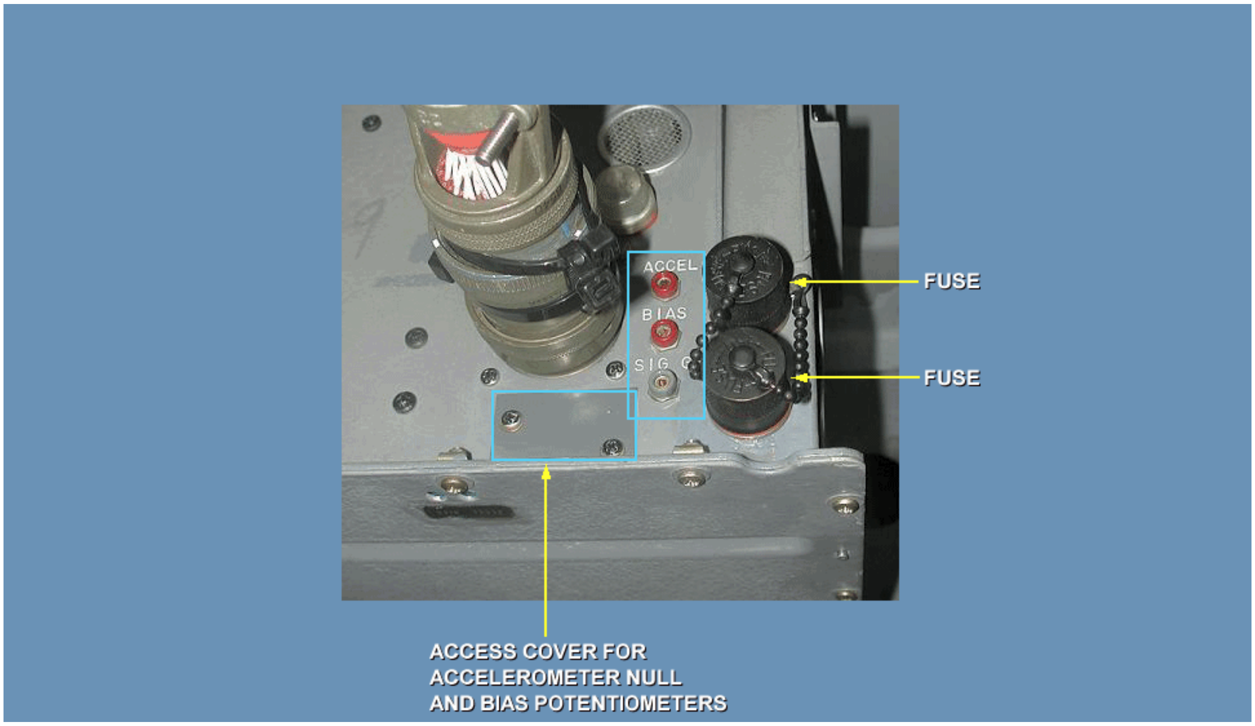
(c) The No. 1 stabilator amplifier receives 115 V ac phase B, from the AC essential bus and 28 V DC from the DC essential bus.

(d) The No. 2 stabilator amplifier receives 115 V ac phase B, from the No. 2 AC primary bus and 28 V dc from the No. 2 DC primary bus.

(e) They also contain fault-monitoring circuitry that disengages the auto mode if a malfunction is detected.

(26) Stabilator Amplifier Test Points

Frame #1252 (Stabilator Amplifier Test Points)

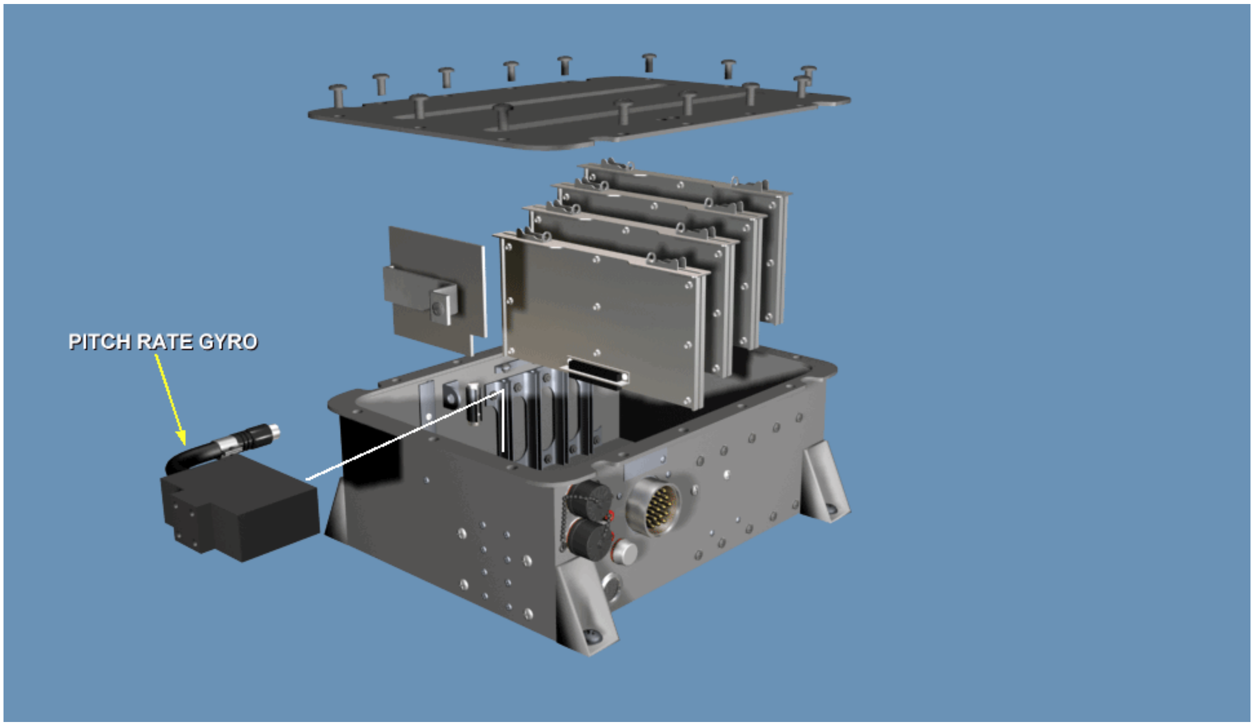


(a) Each stabilator amplifier contains test points for multimeter leads labeled ACCEL, BIAS, SIG GRD, and two potentiometers to facilitate the nulling of the lateral accelerometers and adjustment of amplifier BIAS.

(b) Each stabilator amplifier contains a bias potentiometer that produces a signal to command the stabilator actuators to extend to move the stabilator to about a 37-degree trailing-edge-down when no other signals are present.

(27) Pitch Rate Gyros

Frame #1255 (Pitch Rate Gyros)



(a) Each of the stabilator amplifiers contain a pitch rate gyro.

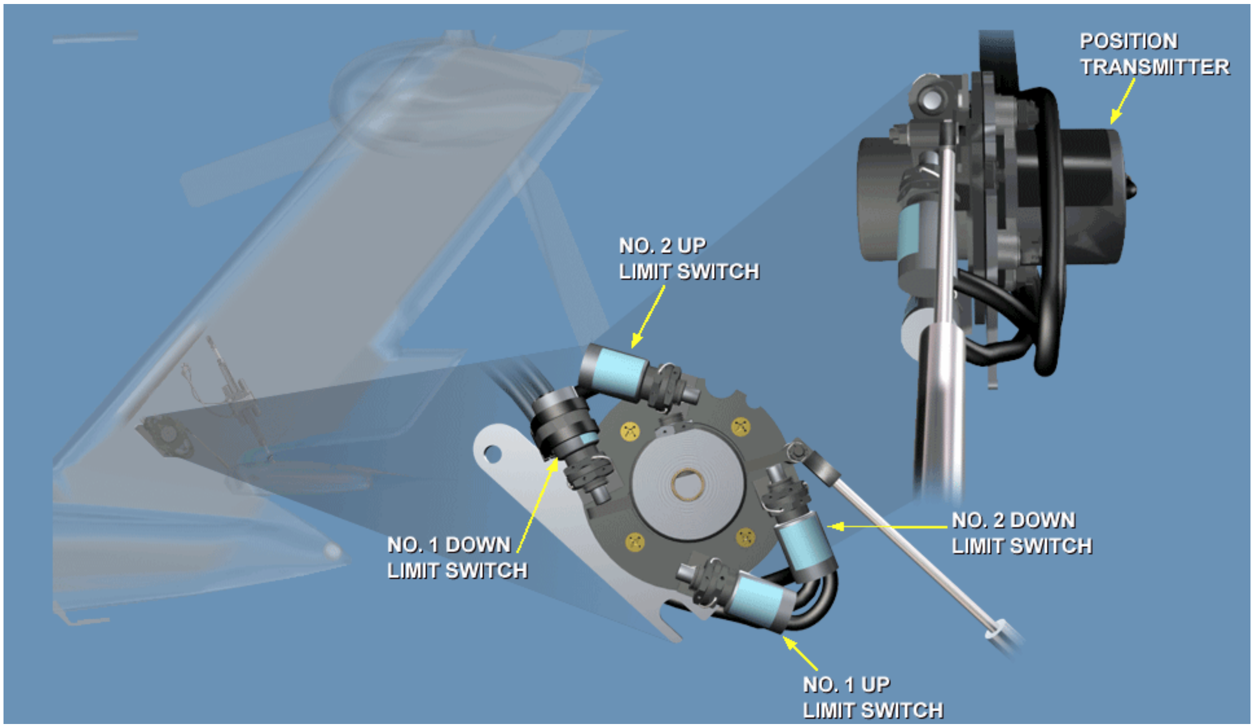
(b) They both receive 15 V dc excitation voltage from the respective stabilator amplifier.

(c) Positive output voltage corresponds to a nose high condition, while a negative voltage corresponds to a nose down condition.

(d) They sense the rate of pitch attitude change of the helicopter and provide pitch dampening at a rate of 1.5 degrees of stabilator movement per 10 degrees/second.

(28) Position Transmitter/Limit Switch Assembly

Frame #1260 (Position Transmitter/Limit Switch Assembly)



(a) The position transmitter/limit switch assembly is located in the tail pylon with a shaft connected to the stabilator.

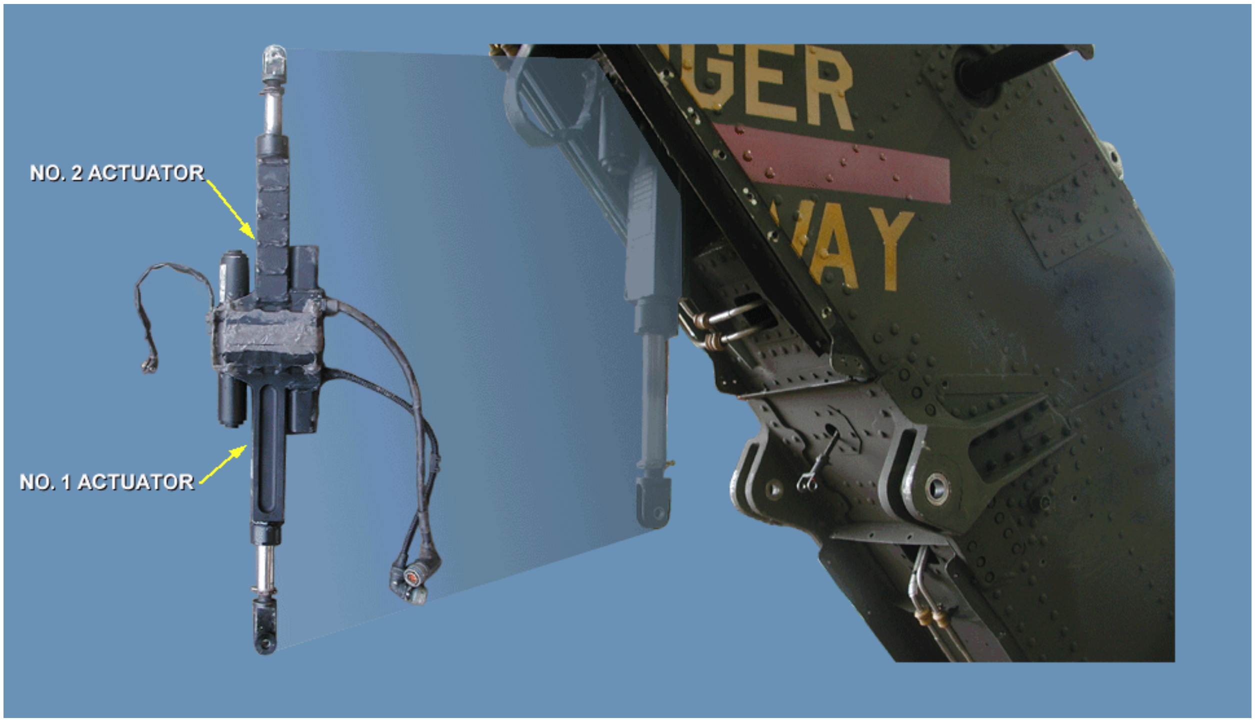
(b) The position transmitter produces a signal that drives the pilot and copilot stabilator position indicators.

(c) The four limit switches prevent the actuators from driving the stabilator to a point where it would contact the fuselage.

(d) When the up or down limit is reached, the appropriate limit switch closes and applies 28 V dc to the limit relays in each stabilator amplifier.

(29) Stabilator Actuator

Frame #1265 (Stabilator Actuators)



(a) The two-stabilator actuators are identical DC electromechanical jackscrew actuators, connected back to back, with the No. 2 actuator connected to the tail pylon and the No. 1 actuator connected to the upper surface of the stabilator.

(b) A feedback potentiometer on each actuator produces a signal that represents the position of the actuator, and is sent to both stabilator amplifiers.

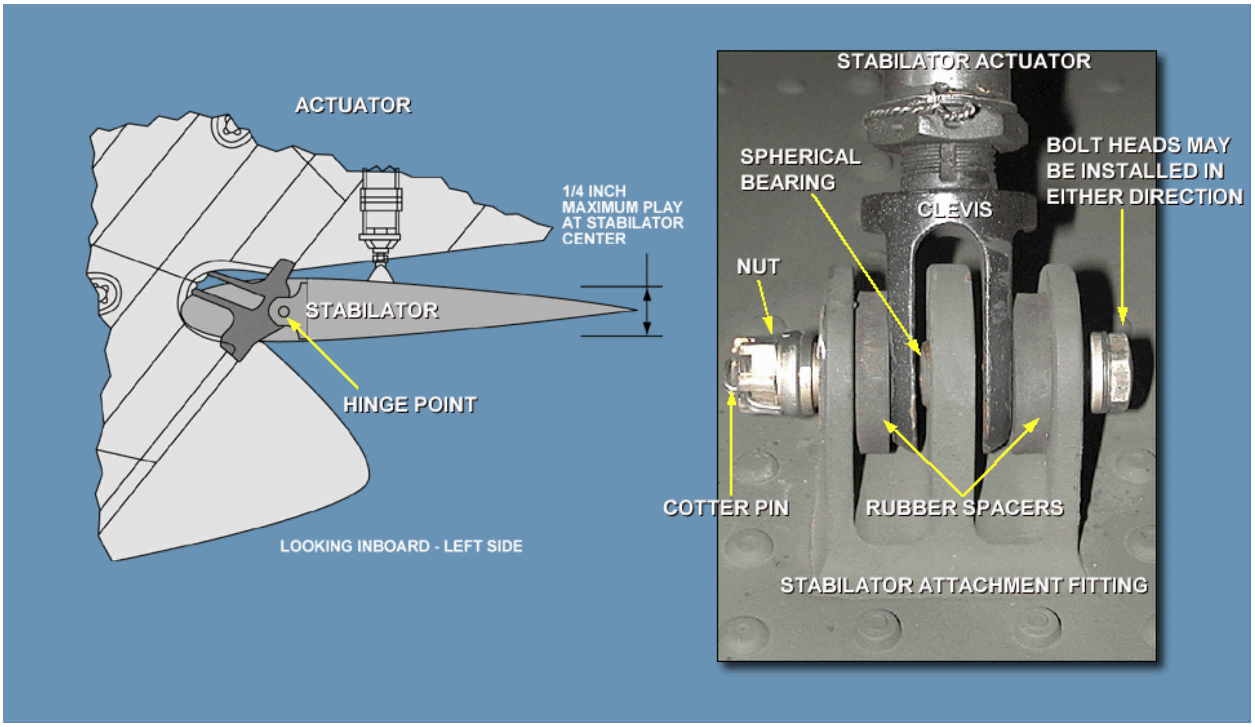
(c) The actuators move at a rate of 7.5 degrees per second, extending or retracting to move the stabilator to the required position, and contain internal limit switches, which limit the actuator travel to 30-35 degrees.

(d) When the actuators retract, the stabilator is moved trailing edge up.

(e) When the actuators extend, the stabilator is moved trailing edge down.

(30) Stabilator Attachment Fitting

Frame #1270 (Stabilator Attachment Fitting)



(a) An additional check not shown above, with stabilator at 0 degrees, the stabilator up and down free play at left and right tip caps, shall not be more than 5/16 on either side.

(b) If movement is greater than specified, check end play and side play in actuator assembly, and check for loose actuator fittings or loose stabilator hinge fittings.

CHECK ON LEARNING

1. The rate gyro assembly contains ______?

2. The left hand weight on wheels switch enables the self test feature on _______.

3. What type of damage does the thermal relief valve on the pilot assist module provide protection from?

4. What are each stabilator amplifiers bias potentiometers adjusted to achieve?

5. What rate of speed do the stabilator actuators move at?

SECTION III. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the function of the Automatic Flight Control System and subsystems topic.

The key points to remember are:

- The AFCS enhances the stability and handling qualities of the helicopter using conventional helicopter flight controls and reduces pilot workload by providing dynamic stability in which porpoising, rocking, fishtailing and skidding are reduced or eliminated.
- The analog stability augmentation system, identified as SAS 1, provides short term correction and rate damping in the pitch, roll, and yaw axis and also provides limited attitude hold in the roll axis.
- The SAS amplifier is the central controller for SAS 1 operation and has no diagnostic capability.
- The digital AFCS system provides the following functions: Digital stability augmentation system, flight path stabilization, and trim system.
- The SAS/FPS computer is the central controller for all the digital AFCS functions and has diagnostic capability.
- The following systems must be on and operational for FPS to function at 100%: SAS 1 and/or SAS 2, Boost, TRIM. The stabilator in the AUTO mode enhances FPS operation, but is not required.
- The Trim system provides a cyclic (pitch and roll) stick and pedal (yaw) flight control force feel and position hold.
- The stabilator control portion of the AFCS control panel provides for manual stabilator control, re-engagement of the automatic mode, and a self-test of the stabilator system. The automatic mode will allow the stabilator to be automatically operated from about 39 degrees trailing edge down to 9 degrees trailing edge up. Manual operation is also restricted to these limits.

B. ENABLING LEARNING OBJECTIVE ELO No. 2

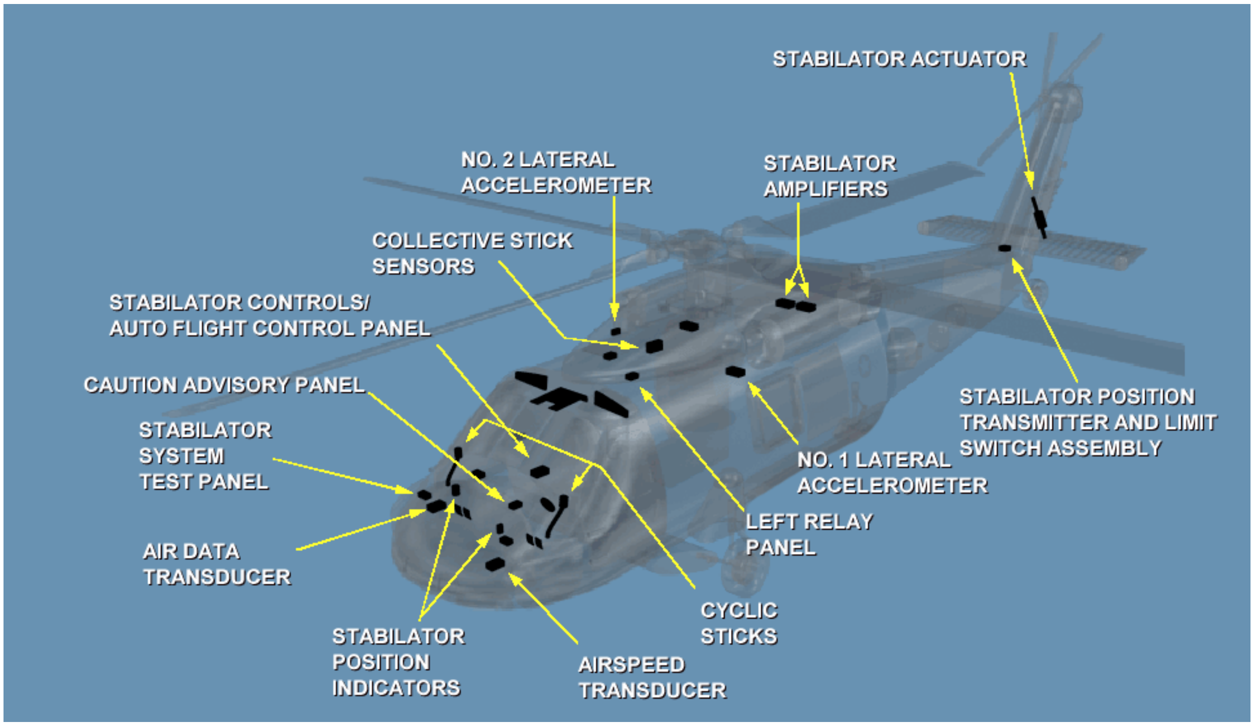
ACTION: Identify the characteristics of the Stabilator Control System.

CONDITION: As an UH-60 Maintenance Test Pilot.

STANDARD: Using TM 1-1520-237-10, TM 1-1520-237-23-2, TM 1-1520-237-MTF, and TM 11-1520-237-23-2

a. Stabilator System Component Review

Frame #2005 (Stabilator System Component Review)



(1) The stabilator system is a dual channel, electromechanical system.

(2) The stabilator system improves flying qualities by positioning the stabilator by means of electromechanical actuators, in response to collective, airspeed, pitch rate, and lateral acceleration inputs.

(3) Automatic Mode

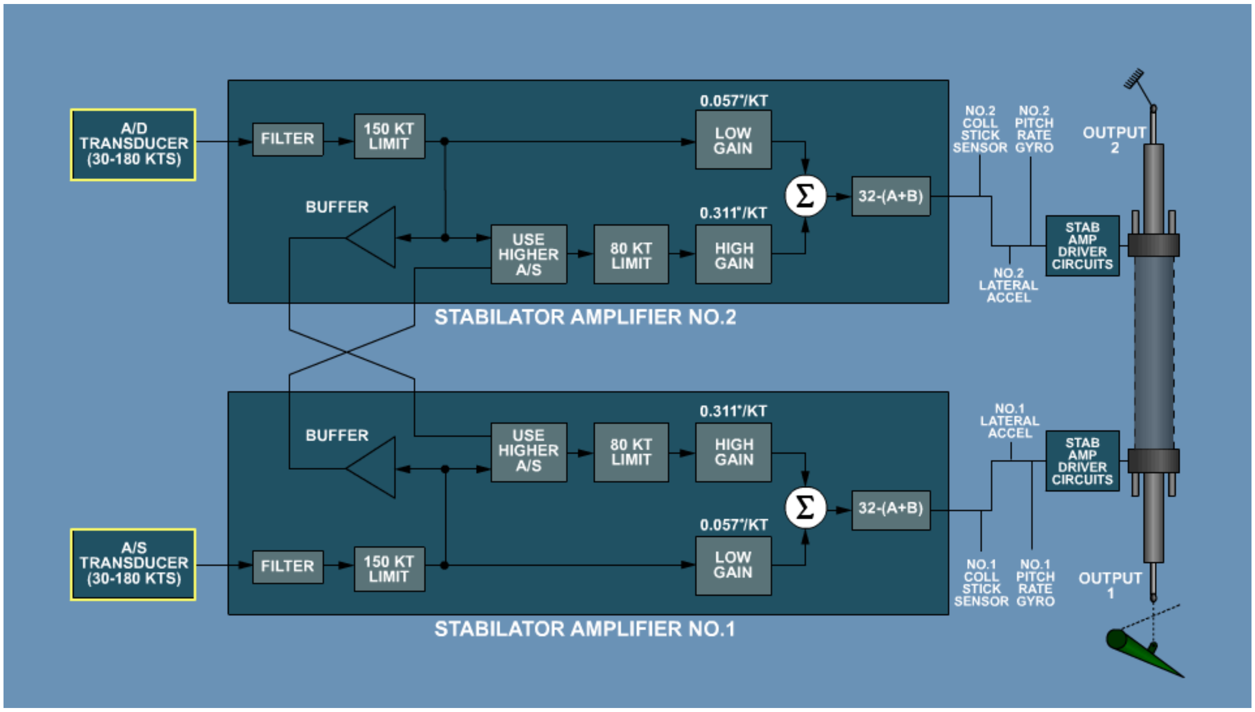
(a) Airspeed and Airdata transducers pass a minimum of 1.75 V dc to the stabilator amplifiers.

(b) Collective stick position sensor interlock.

(c) No “HOT SLEW” command present.

(d) Actuators positions within 10 degrees below 30 KIAS and 4 degrees at 150 KIAS.

Frame #2015 (Stabilator Scaling Amplifier Circuit)



(e) Each stabilator amplifier has two airspeed signal gain paths.

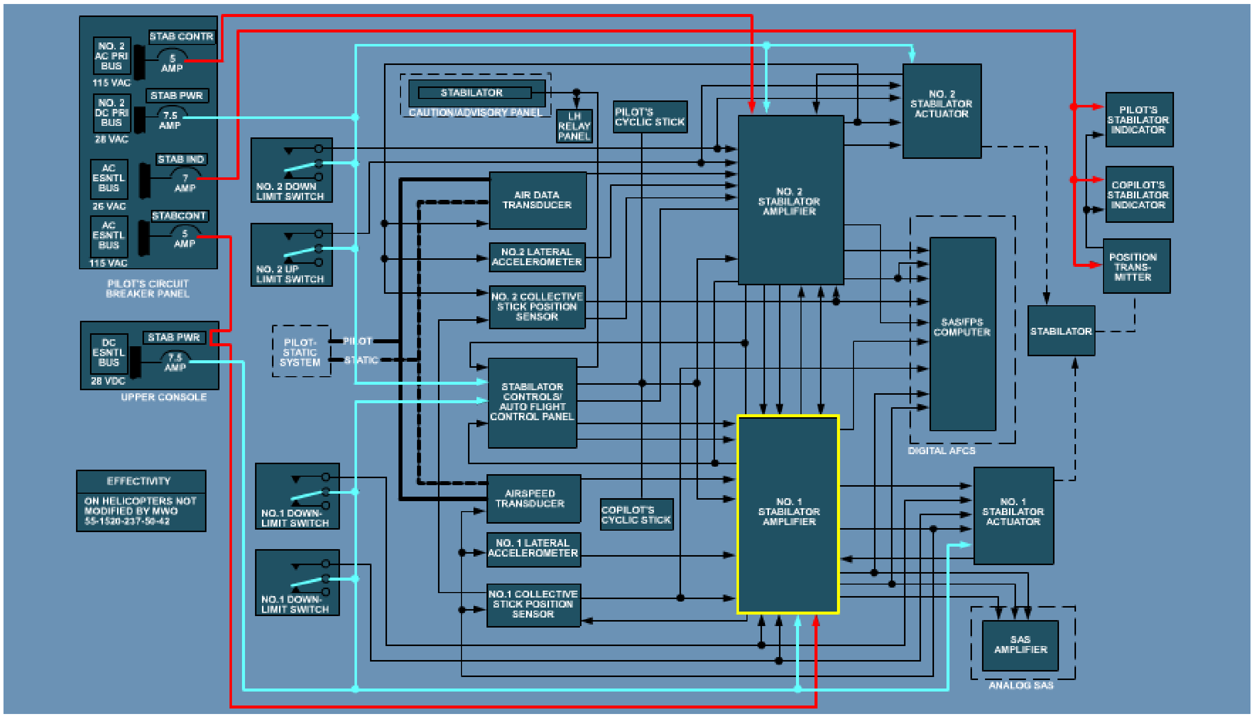
(f) The low airspeed gain path uses the airspeed sensor discrete signal as an input to the scaling amplifier circuit.

(g) This discrete signal is also buffered and sent to the other stabilator amplifier as AS BFR OS.

(h) The buffered airspeed signal or the discrete airspeed signal will derive the high airspeed gain path.

(i) The OR circuit assures that the higher airspeed signal will be used in each stabilator amplifier.

Frame #2020 (Automatic Mode FLASH)



(j) The automatic mode of operation positions the stabilator to the best position for existing flight conditions, with no inputs from the pilot.

(k) The automatic mode engages automatically when electrical power is applied and certain interlocks exist.

(l) With electrical power applied, the No. 1 stabilator amplifier applies a 28 V dc automatic mode engage/interlock signal through the No. 1 and No. 2 collective stick position sensors to the No. 2 stabilator amplifier.

(m) The No. 2 amplifier also applies a 28 V dc automatic mode engage signal to the No. 1 amplifier.

(n) With the engage signals present, each amplifier also applies 28 V dc driver supply power to the other amplifier and to the stabilator controls/auto flight control panel.

(o) Each amplifier sends 15 V dc excitation to each of the stabilator actuators, the air data transducer/airspeed transducer, the No. 2/No. 1 accelerometers, and the No. 2/No. 1 collective stick sensors.

(p) Airspeed and air data transducer signal inputs to the stabilator amplifiers are also required for automatic mode engagement.

(q) For airspeeds between 0 and 30 knots, the output of each transducer is about 2.25 V dc.

(r) If the output of either transducer is less than 1.7 V dc, the automatic mode engage signal from the associated amplifier will be inhibited and the automatic mode will not engage.

(s) With both amplifier driver supply voltages applied to the control panel, two auto engage relays are energized and the AUTO CONTROL RESET switch ON legend goes on.

(t) For automatic mode operation, each amplifier receives airspeed, collective position and lateral acceleration signals.

(u) At airspeeds below 30 knots, no signals are passed.

(v) At airspeeds greater than 60 knots, maximum signals are passed.

(w) The collective stick position and lateral acceleration signals are faded in as airspeed increases from 30 to 60 knots.

(x) The airspeed transducer signal to the No. 1 stabilator amplifier and the air data transducer signal to the No. 2 stabilator amplifier are used as an input to the scaling amplifier circuit internal of each amplifier.

(y) This signal is also buffered and sent to the other stabilator amplifier.

(z) The buffered airspeed signals are compared to each amplifiers airspeed input signal and the higher of the two is used as the high gain signal.

(aa) An OR circuit then compares this high gain signal to each amplifiers airspeed input (low gain) and assures that the highest of the two is used as an output to the driver circuits.

(bb) The pitch rate signals from pitch rate gyros located within each of the amplifiers, are combined with the airspeed, collective stick position, and lateral acceleration signals to provide input signals to the stabilator amplifier driver circuits.

1) The driver circuits produce 28 V dc motor extend/retract signals that are applied to the stabilator actuators.

2) In flight, the airspeed, collective stick position, pitch rate and lateral acceleration signals determine the position to which the stabilator will move.

3) On the ground, these signals are close to zero.

4) Each stabilator amplifier contains a bias potentiometer that produces a signal to command the stabilator actuators to extend to move the stabilator to about a 37 degree trailing-edge-down when no other signals are present.

5) The Stabilator position continuously monitored by a position transmitter/limit switch assembly that is mechanically linked to the stabilator.

6) The position synchro transmitter produces a signal that drives the pilot and copilot stabilator indicators.

7) The four limit switches on the assembly prevent the actuators from driving the stabilator to a point where it would contact the fuselage.

8) When the stabilator up or down limit is reached, the No. 1 and No. 2 up or down limit switches close and apply 28 V dc to limit relays in each stabilator amplifier.

9) These limit relays remove power to one side of the actuator motors, preventing the actuators from driving any further in the limit direction.

10) Additional limit switches, internal of each actuator, will energize the limit relays to prevent actuator extension or retraction beyond safe mechanical limits

11) Each stabilator actuator contains a feedback potentiometer that provides actuator position signals to both stabilator amplifiers.

12) The actuator position signals are compared in each amplifier and an error signal is generated if the positions do not agree.

13) The error signal is applied to a fault circuit whose trip level depends on airspeed.

14) A trip of the fault circuit in either amplifier removes the driver supply voltage to both amplifiers, de-energizes the auto engage relays in the control panel, and turns off the AUTO CONTROL RESET switch ON legend.

15) At airspeeds of 0 to 30 knots, the fault circuit will trip with an actuator position error of about 10°.

16) At airspeeds of 150 knots and above, the circuit will trip with a position error of about 4°.

17) The control panel also applies an automatic mode failure signal to the caution/advisory panel to light the STABILATOR capsule and to the LH relay panel to start a beeping warning tone in the pilot and copilot headsets.

18) The warning tone can be stopped by pressing the master warning panel MASTER CAUTION PRESS TO RESET capsule.

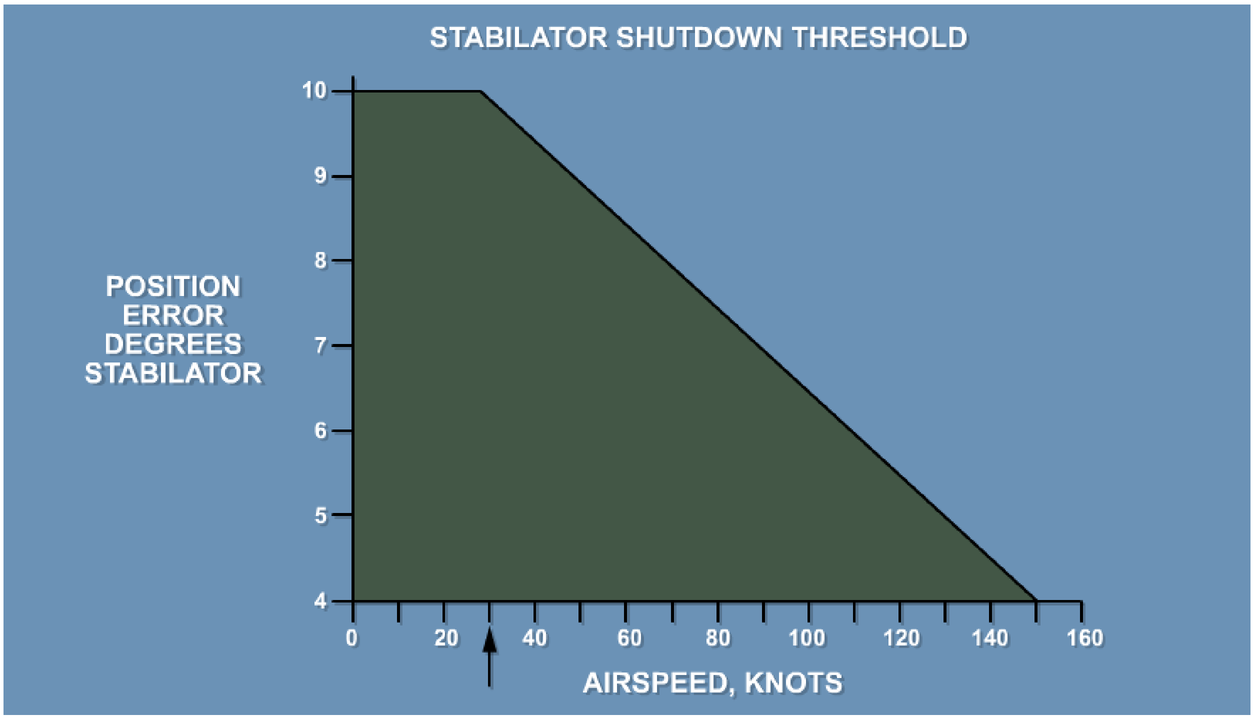
19) For a further description of the warning tone circuit, refer to caution/advisory warning system in TM 55-1520-237-23-2.

20) Reengagement of the automatic mode can be attempted by pressing the AUTO CONTROL RESET switch.

21) This applies an auto control reset signal to each stabilator amplifier to initiate the automatic mode engage signals if the failure has been corrected.

22) Stabilator Shutdown Threshold

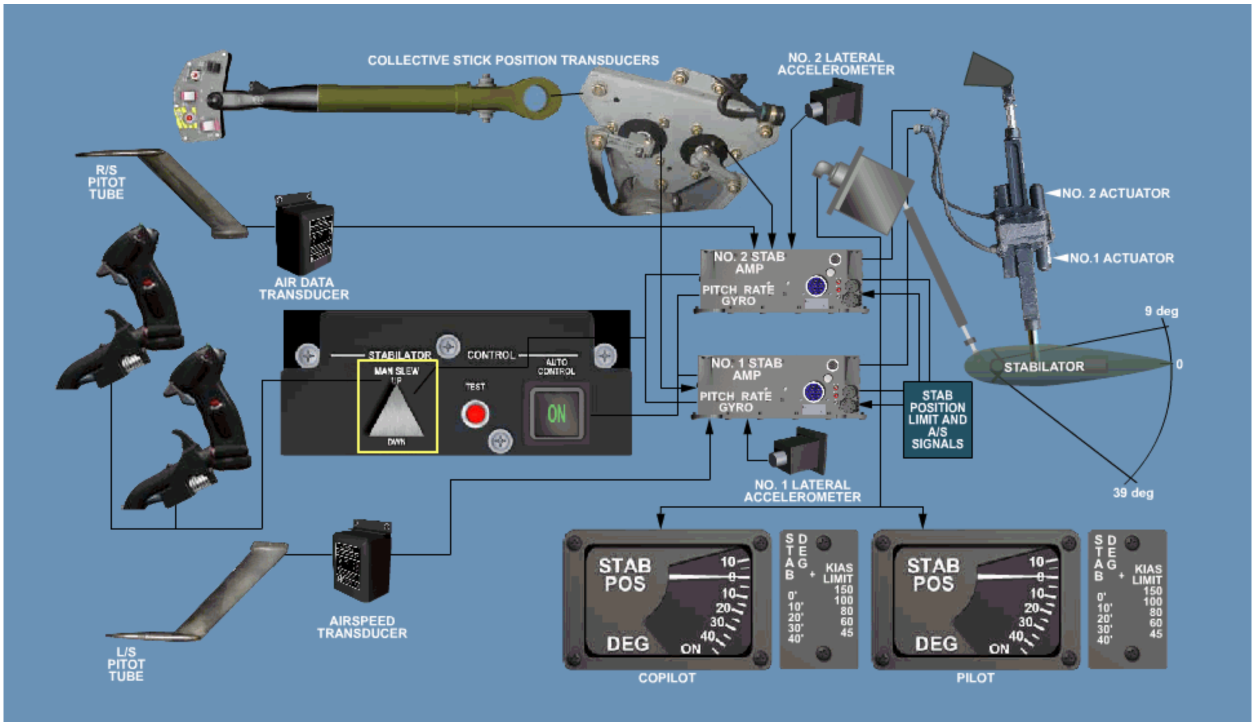
Frame #2025 (Stabilator Shutdown Threshold)



a) If the shutdown threshold is exceeded, a fault circuit will remove the drive voltage and disengage the auto mode.

(cc) Manual

Frame #2040 (Manual Mode FLASH)



1) The manual mode of operation lets the pilot control stabilator positions with the control panel MAN SLEW switch.

2) When the switch is pressed UP or DN, 28 V dc hot slew signals are applied to both stabilator amplifiers to disengage the automatic mode, if it was engaged.

3) The switch also applies 28 V dc slew up or down command signals to the amplifiers.

4) With the MAN SLEW switch pressed UP or DN, the automatic mode of operation cannot be engaged even if no failure is present.

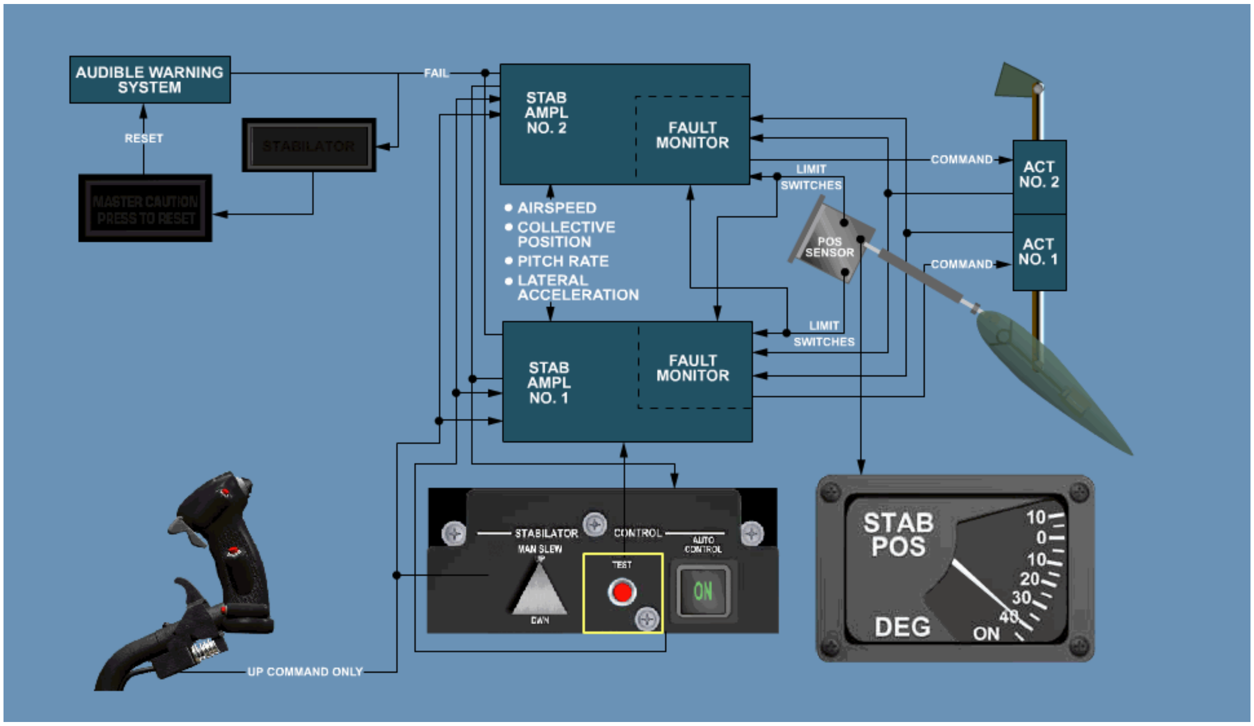
5) The amplifiers apply power to the actuator motors that cause the stabilator to move up or down.

6) Since there is no airspeed input for stabilator control in the manual mode, placards on the instrument panel list the maximum allowable speed for a selected stabilator angle.

7) The slew-up switch mounted on the pilot and copilot cyclic stick operates exactly as the MAN SLEW switch, except only in the up direction.

(dd) System Test

Frame #2030 (Stabilator System Test FLASH)



1) The stabilator system test circuit provides a check of automatic mode shutdown.

2) The TEST switch on the control panel initiates the check at airspeeds less than 60 knots.

3) When the switch is pressed, power is applied to the No. 1 stabilator amplifier.

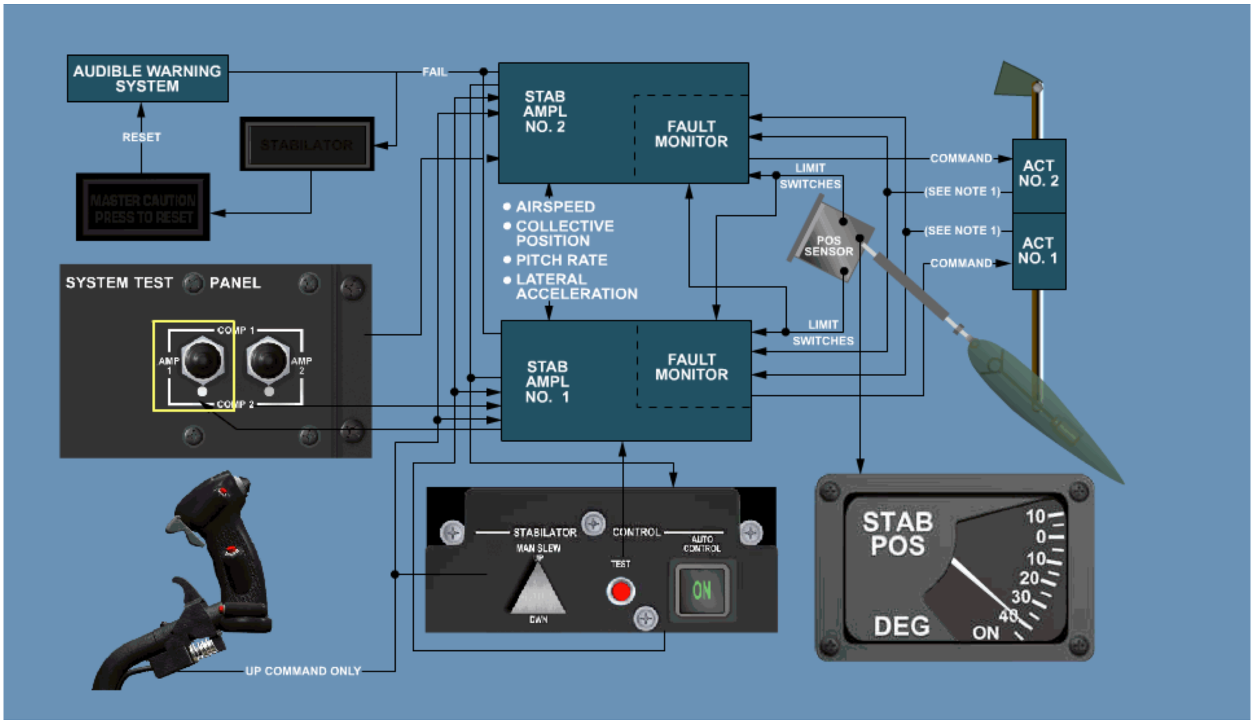
4) The amplifier applies an output to the No. 1 stabilator actuator to move the stabilator about 10 degrees trailing edge up.

5) Since the No. 2 amplifier receives no input to supply the No. 2 actuator, the two-actuator positions disagree.

6) This position error is detected by the No. 1 or No. 2 amplifier fault circuit, and the automatic mode is disengaged.

a) Stabilator Test Panel

Frame #2035 (Stabilator Test Panel FLASH)



1 In helicopters modified by MWO 55-1520-237-50-42, a stabilator test panel provides an additional check of the automatic mode disengagement for actuator position error.

2 The checks for the No. 1 and No. 2 stabilator amplifiers are identical; only the No. 1 amplifier will be described.

3 When AMP 1 switch is momentarily placed in either COMP1 or COMP2 position, a simulated actuator position error signal is applied to the No. 1 amplifier.

4 Since no input signal is applied to the No. 2 amplifier, a position error is detected by the No. 1 amplifier fault circuit and the automatic mode is disengaged.

(d) Stabilator Checks

1) GROUND STABILATOR TEST

a) Checks three slew switches, dual actuator control

b) Checks airframe limiters

c) Pilot /copilot indications

d) Stabilator comparator

e) 100 KNOTS

f) Collective Program

g) 120 KNOTS

h) Stabilator lateral acceleration

i) Pitch rate

j) Vh

k) Program end point (flat region, 0 degree pitch rate, 0 degree lateral acceleration, 100% collective)

2) The above list, is a brief overview of the checks performed on a test flight for the stabilator.

CHECK ON LEARNING

1. The stabilator is repositioned to improve the flying qualities of the aircraft by the use of ______?

2. What signals must be present for the automatic mode of the stabilator system to engage when electrical power is applied to the aircraft?

3. On the ground, what drives the stabilator to about a 37 degree trailing-edge-down when no other signals are present?

4. What happens if the stabilator shut down threshold is exceeded?

5. What does the stabilator system test circuit provide?

SECTION IV. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the characteristics of the Stabilator Control System topic.
The key points to remember are:

- The stabilator system is a dual channel, electromechanical system.
- The stabilator system improves flying qualities by positioning the stabilator by means of electromechanical actuators, in response to collective, airspeed, pitch rate, and lateral acceleration inputs.
- For automatic mode operation, each amplifier receives:
  - Airspeed signals.
  - Collective position signals.
  - Lateral acceleration signals.
  - At airspeeds below 30 knots, no signals are passed. At airspeeds greater than 60 knots, maximum signals are passed.
  - The collective stick position and lateral acceleration signals are faded in as airspeed increases from 30 to 60 knots.
- Each stabilator amplifier contains a bias potentiometer that produces a signal to command the stabilator actuators to extend to move the stabilator to about a 37 degree trailing-edge-down when no other signals are present.
- Each stabilator actuator contains a feedback potentiometer that provides actuator position signals to both stabilator amplifiers. The actuator position signals are compared in each amplifier and an error signal is generated if the positions do not agree.
- The stabilator system test circuit provides a check of automatic mode shutdown. The TEST switch on the control panel initiates the check at airspeeds less than 60 knots.

C. ENABLING LEARNING OBJECTIVE ELO No. 3

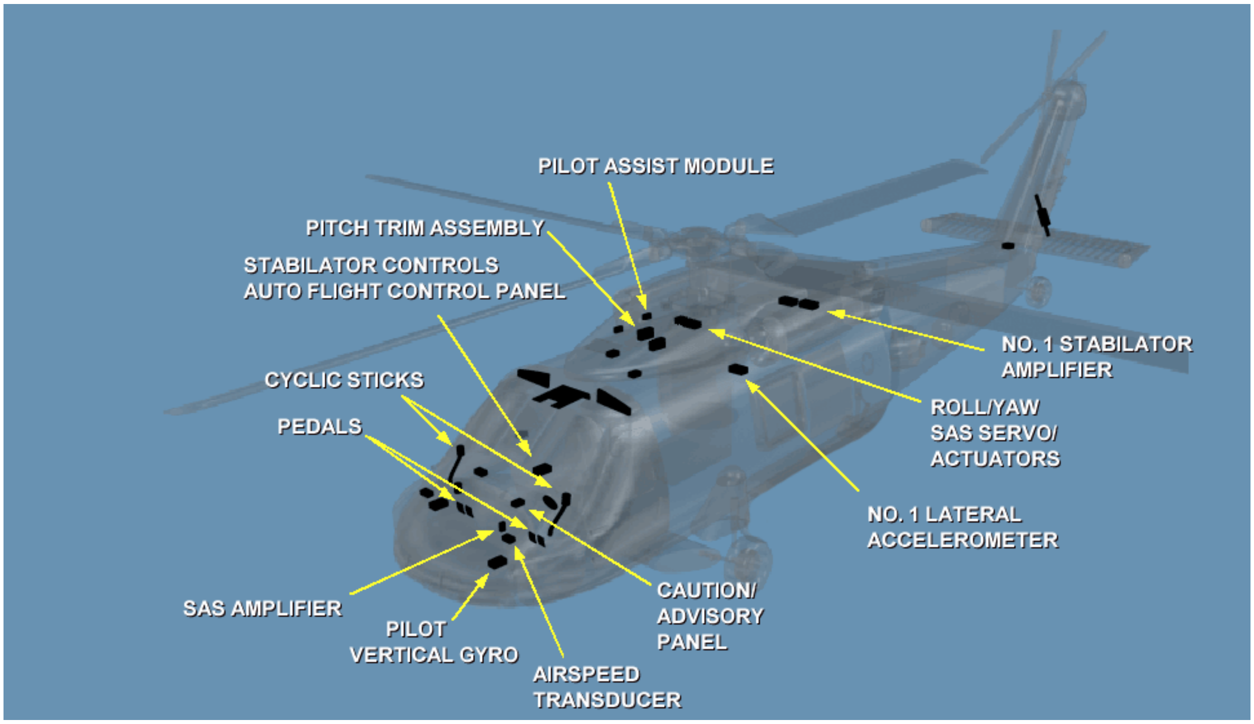
ACTION: Identify the characteristics of the Stability Augmentation System (SAS 1).

CONDITION: As an UH-60 Maintenance Test Pilot

STANDARD: Using TM 1-1520-237-10, TM 1-1520-237-23-2, TM 1-1520-237-MTF, and TM 11-1250-237-23-2.

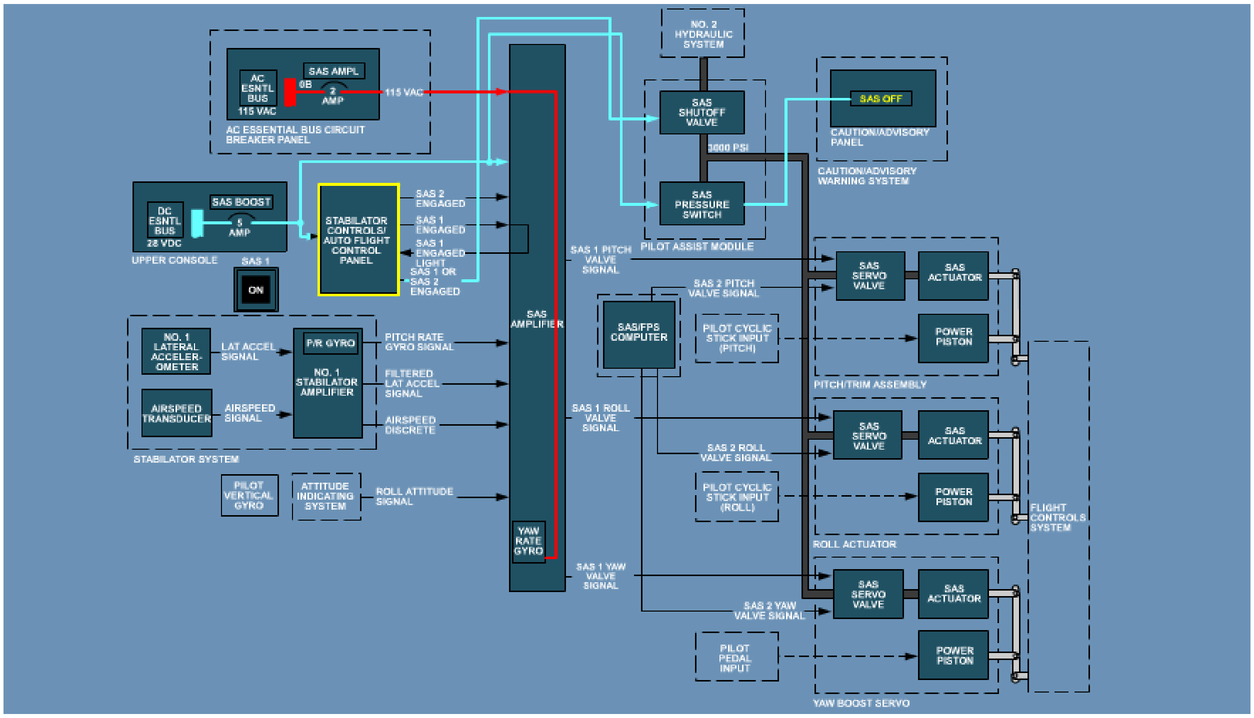
a. SAS 1 Component Refresher

Frame #3005 (SAS 1 Component Refresher)



b. SAS 1 Operation

Frame #3010 (SAS 1 System FLASH)



(1) The SAS 1 system gets 28 V dc electrical power from the upper console circuit breaker panel dc essential bus, through the SAS BOOST circuit breaker, and ac electrical power from the 115 V ac essential bus circuit breaker panel through the SAS AMPL circuit breaker.

(2) The SAS amplifier transforms this 115 V ac to 26 V ac for yaw rate gyro excitation and demodulator reference voltage.

(3) The SAS shutoff valve in the pilot assist module receives 28 V dc from the SAS 1 and SAS 2 switches on the stabilator controls/auto flight control panel.

(4) This closes the shutoff valve, removing hydraulic pressure from the SAS servo valves and illuminating the SAS OFF capsule on the caution advisory panel.

(5) When the control panel SAS 1 switch is engaged, 28 V dc is applied to the SAS amplifier to energize output relays, and also from the amplifier back to the control panel to light the SAS 1 switch ON legend.

(6) When SAS 1 (or SAS 2) is engaged, the 28 V dc is removed from the SAS shutoff valve, and the valve opens.

(7) Hydraulic pressure, at 3000 psi, is supplied by the No. 2 hydraulic system to the SAS servo valves and the SAS pressure switch opens to turn off the SAS OFF capsule on the caution/advisory panel.

(8) The pitch rate gyro, in the No. 1 stabilator amplifier, senses changes in the pitch attitude and applies a pitch rate signal to the SAS amplifier.

(9) The amplifier processes this signal to provide a correction signal that is applied to the pitch/trim assembly SAS servo valve.

(10) The servo valve regulates the hydraulic pressure applied to the SAS actuator to control the movement of the actuator output rod.

(11) The actuator output rod is mechanically connected to the flight controls that produce the rotor head movements to oppose the pitch attitude change sensed by the pitch rate gyro.

(12) An AC roll attitude signal, from the pilots vertical gyro, is applied to the SAS amplifier.

(13) The SAS amplifier transforms this signal to a DC roll attitude signal from which it derives a roll rate signal and a limited roll proportional signal.

(14) The derived rate signal provides short term roll attitude correction.

(15) The limited proportional signal holds the helicopter in a level roll attitude.

(16) The polarity and amplitude of the proportional signal depends on the direction and amount respectively of displacement from a level attitude.

(17) The rate and proportional signal are added in the SAS amplifier and the resultant signal is applied to the roll actuator SAS servo valve to control the SAS actuator and, in turn, the flight controls.

(18) The SAS amplifier contains a yaw rate gyro that senses changes in yaw attitude.

(19) At airspeeds less than 60 knots, as determined by an airspeed discrete signal from the No. 1 Stabilator amplifier, only the yaw rate gyro output is processed to produce a short term correction signal.

(20) At airspeeds greater than 60 knots, the system enhances turn coordination by adding the No. 1 filtered lateral accelerometer and derived roll rate signals to the yaw rate gyro signal.

(21) The amplifier output is applied to the yaw boost servo SAS servo valve to control the SAS actuator.

(22) Actuator output rod movements result in changes in tail rotor pitch for yaw correction.

(23) The SAS amplifier contains a yaw rate gyro that senses changes in yaw attitude.

(24) At airspeeds less than 60 knots, as determined by an airspeed discrete signal from the No. 1 Stabilator amplifier, only the yaw rate gyro output is processed to produce a short term correction signal.

(25) At airspeeds greater than 60 knots, the system enhances turn coordination by adding the No. 1 filtered lateral accelerometer and derived roll rate signals to the yaw rate gyro signal.

(26) The amplifier output is applied to the yaw boost servo SAS servo valve to control the SAS actuator.

(27) Actuator output rod movements result in changes in tail rotor pitch for yaw correction.

(28) The SAS 1 signals applied to the SAS servo valves result in rotor blade angle changes only and do not cause movement or the cyclic sticks or pedals.

(29) With both SAS 1 and SAS 2 engaged, the SAS actuators each have 10% authority to flight control movement, with each SAS having 5 %.

(30) With SAS 1 or SAS 2 disengaged, the gain of the remaining engaged system is doubled to maintain stability authority, while its authority remains at 5%.

CHECK ON LEARNING

1. Which hydraulic system supplies 3000 psi to the SAS servo valves?

2. The pitch channel uses what gyro as an input when SAS 1 is engaged?

3. The proportional signal in the SAS 1 roll channel is comprised of what two signals?

4. What signal in the yaw channel determines whether the yaw rate and derived roll rate is passed above 60 knots?

SECTION V. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the characteristics of the Stability Augmentation System (SAS 1) topic.

The key points to remember are:

- When SAS 1 (or SAS 2) is engaged, the 28 V dc is removed from the SAS shutoff valve, and the valve opens.
- Hydraulic pressure, at 3000 PSI, is supplied by the No. 2 hydraulic system to the SAS servo valves and the SAS pressure switch opens to turn off the SAS OFF capsule on the caution/advisory panel.
- The pitch rate gyro, in the No. 1 stabilator amplifier, senses changes in the pitch attitude and applies a pitch rate signal to the SAS amplifier. The amplifier processes this signal to provide a correction signal that is applied to the pitch/trim assembly SAS servo valve.
- An AC roll attitude signal, from the pilots vertical gyro, is applied to the SAS amplifier. The SAS amplifier transforms this signal to a DC signal and combines it with the filtered lateral accelerometer signal from the stabilator system to produce a proportional signal.
- The SAS amplifier contains a yaw rate gyro that senses changes in yaw attitude.
- A derived roll rate signal from the combined filtered lateral accelerometer and the pilot vertical gyro signals, is sent to the yaw channel. At airspeeds less than 60 knots, as determined by an airspeed discrete signal from the No. 1 Stabilator amplifier, only the rate gyro output is processed to produce a short term correction signal. At airspeeds greater than 60 knots, the system enhances turn coordination by adding the lateral accelerometer and derived roll rate signals to the rate gyro signal.

D. ENABLING LEARNING OBJECTIVE ELO No. 4

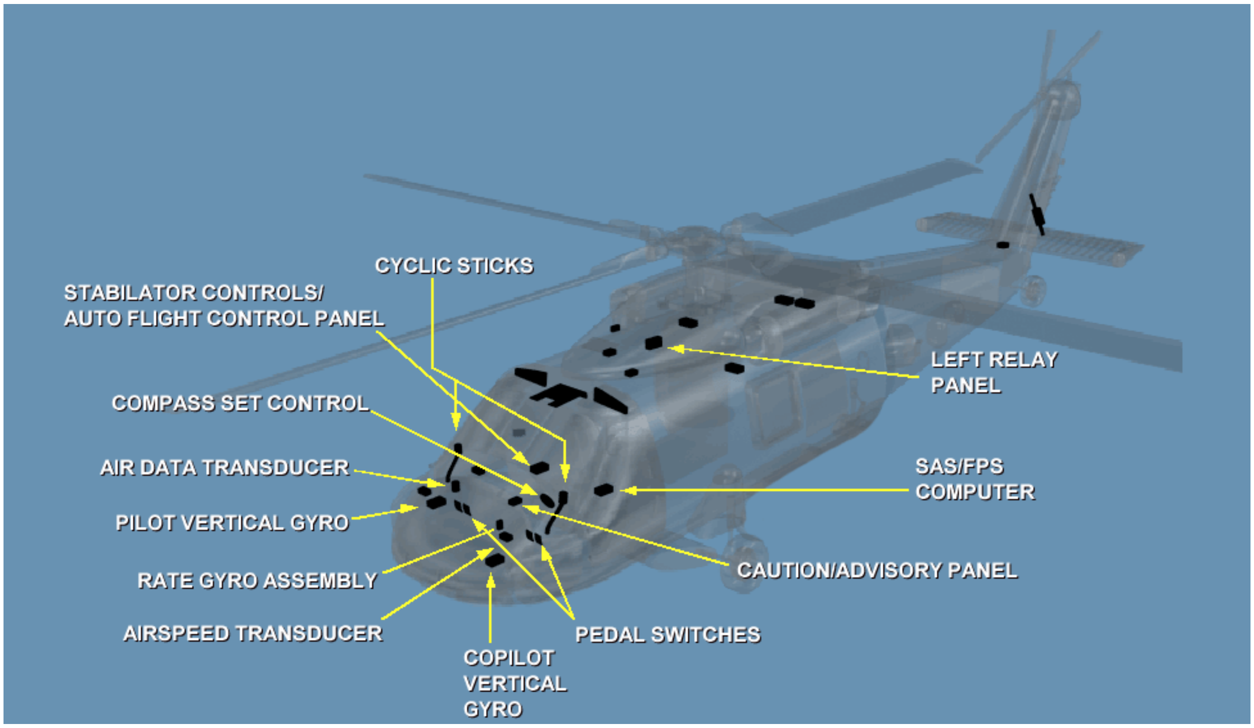
ACTION: Identify the characteristics of the Digital AFCS System.

CONDITION: As an UH-60 Maintenance Test Pilot.

STANDARD: Using TM 1-1520-237-10, TM 1-1520-237-23-2, TM 1-1520-237-MTF, and TM 11-1250-237-23-2.

a. Digital AFCS Component Review

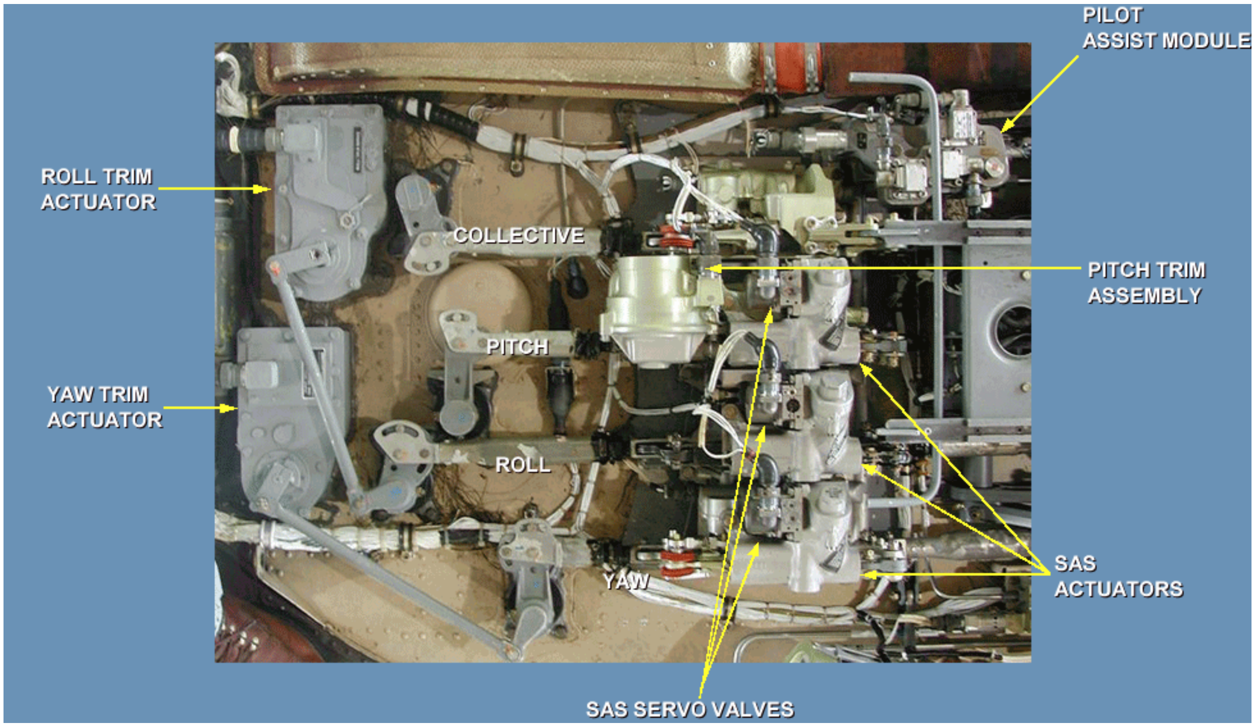
Frame #4005 (Digital AFCS Component Review)



(1) The trim function provides cyclic (pitch and roll) and pedal (yaw) flight control position reference and control gradient, to maintain cyclic stick and pedals at a desired position.

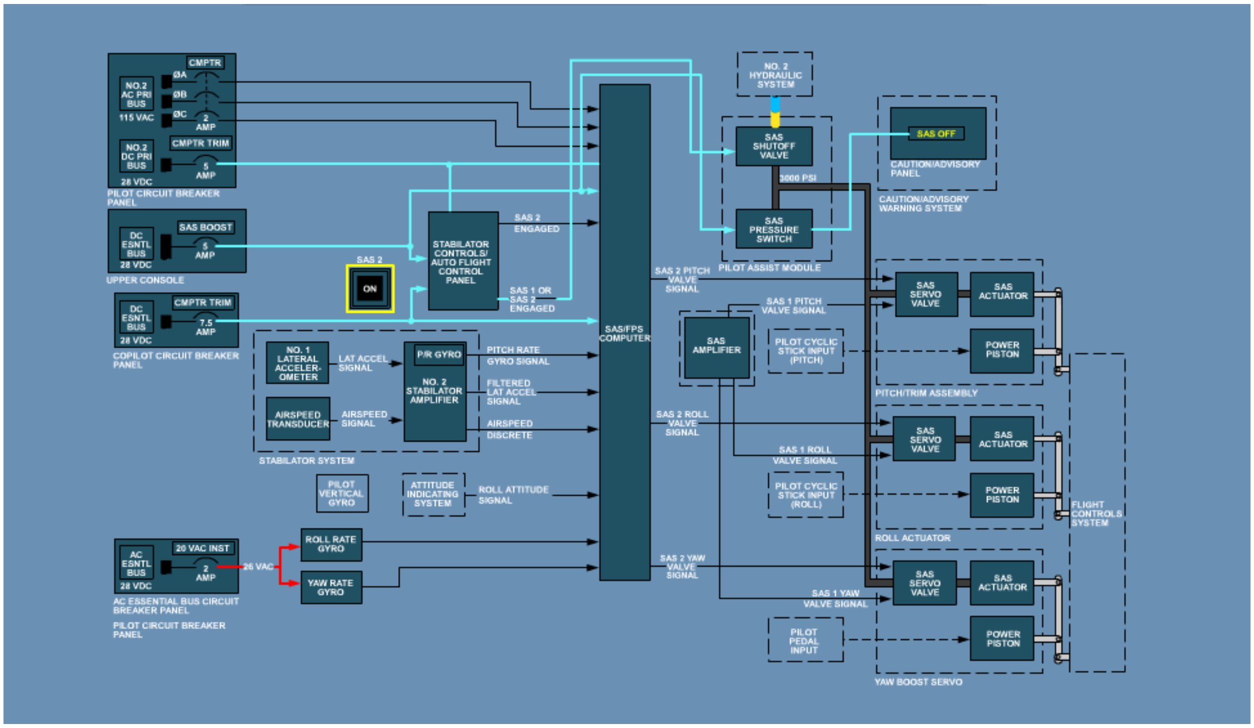
b. Transmission/Upper-Deck Component Review

Frame #4010 (Transmission/Upper Deck Component Review)



c. Stability Augmentation System 2 (SAS 2)

Frame #4200 (SAS 2 Schematic FLASH)



(1) Digital stability system (SAS 2) provides short-term correction and rate damping signals to the flight controls for pitch, roll, and yaw stability, and provides limited attitude hold in the roll axis.

(2) Digital SAS is engaged by pressing the control panel SAS 2 button switch.

(3) When engaged, the switch ON legend is illuminated.

(4) With SAS 2 (or SAS 1) engaged, the 28 V dc is removed from the SAS shutoff valve, and the valve opens, routing hydraulic pressure to the SAS pressure switch, turning off the SAS OFF caution capsule and to the pitch, roll and yaw SAS servo valves.

(5) The SAS 2 pitch channel uses the pitch rate gyro signal from the No. 2 stabilator amplifier to sense the direction and rate of longitudinal helicopter movement.

(6) The resultant correction signal from the computer has a polarity and amplitude proportional to the direction and rate, respectively, of the input signal.

(7) The correction signal is applied to the SAS servo valve which produces an action in the flight controls that opposes the movement sensed by the rate gyro.

(8) The SAS 2 roll channel uses the output of the roll rate gyro to produce a short-term correction signal.

(9) It also uses the No. 1 vertical gyro roll signal from the pilot vertical gyro to produce a proportional signal that holds the helicopter in a level roll attitude, the polarity and amplitude of the proportional signal depends on the direction and amount respectively, of displacement from a level attitude.

(10) The proportional signal is added to the rate signal, and the resultant is applied to the roll SAS servo valve.

(11) The attitude hold function is limited to 1.2% of SAS 2 authority and is disabled at roll attitudes greater than 7 degrees.

(12) The sensors used by the SAS yaw channel are determined by helicopter airspeed.

(13) Below 60 knots airspeed, the computer uses only the yaw rate gyro signal to sense the direction and rate of yaw movement.

(14) The signal is processed to provide a correction signal to the SAS actuator that opposes the heading change.

(15) Above 60 knots, the computer adds input signals from the No. 1 lateral accelerometer and the No. 1 vertical gyro (derived rate) to stabilize yaw during coordinated turns.

(16) The SAS servo valves controls the SAS actuator output rod on the yaw boost servo.

(17) The servo is mechanically connected to the flight controls that affect tail rotor blade pitch.

(18) The sensors used by the SAS yaw channel are determined by helicopter airspeed.

(19) Below 60 knots airspeed, the computer uses only the yaw rate gyro signal to sense the direction and rate of yaw movement.

(20) The signal is processed to provide a correction signal to the SAS actuator that opposes the heading change.

(21) Above 60 knots, the computer adds input signals from the No. 1 lateral accelerometer and the No. 1 vertical gyro (derived rate) to stabilize yaw during coordinated turns.

(22) The SAS servo valves controls the SAS actuator output rod on the yaw boost servo.

(23) The servo is mechanically connected to the flight controls that affect tail rotor blade pitch.

(24) The SAS 2 signals applied to the SAS servo valves result in rotor blade angle changes only and do not cause movement of the pilot cyclic sticks or pedals.

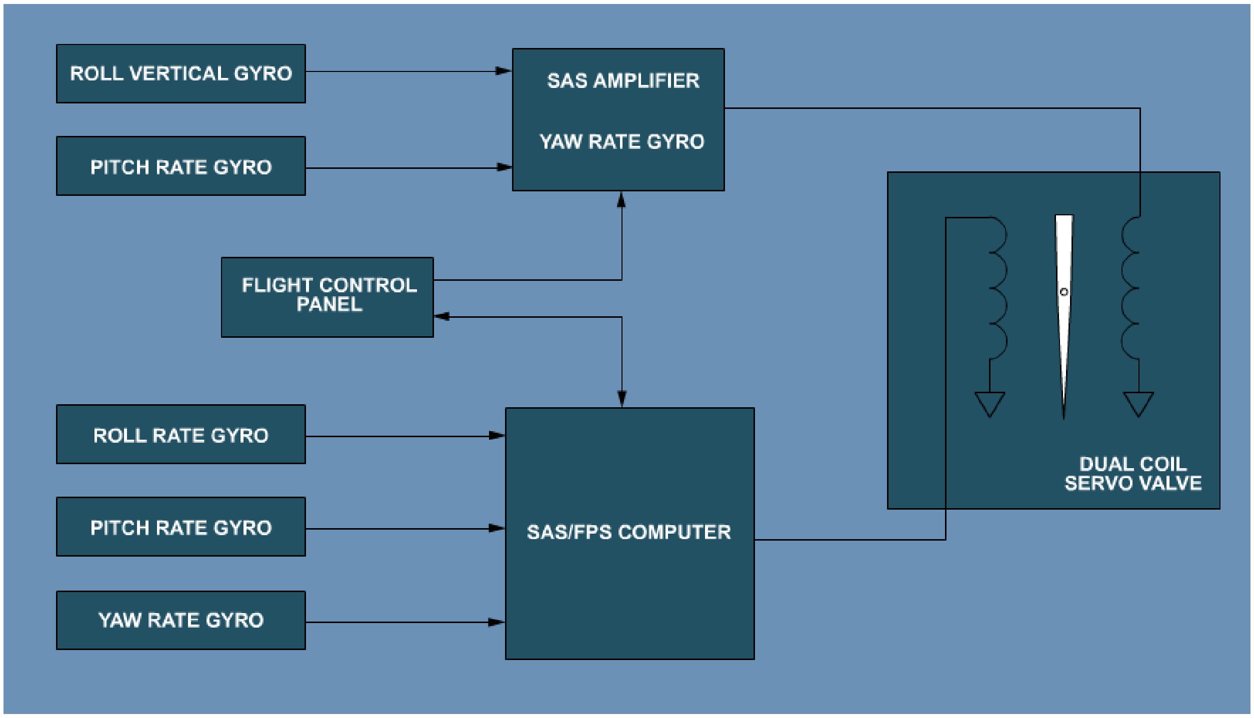
(25) With both SAS 1 and SAS 2 engaged, the SAS actuators have 10% authority of flight control movement, with each SAS system having 5%.

(26) With SAS 1 or SAS 2 disengaged, the gain of the engaged system is doubled to maintain stability control; while its authority remains at 5%.

(27) The stabilator controls/auto flight control panel applies a signal to the SAS/FPS computer to indicate engagement of the SAS 1 system.

(28) Disengagement of SAS 1 removes this signal from the computer, causing the gain of the SAS 2 signals to double.

Frame #4210 (SAS 1/SAS 2 Interface)



(29) With both SAS 1 and SAS 2 engaged, the SAS actuators each have 10% authority to flight control movement, with each SAS system having 5%.

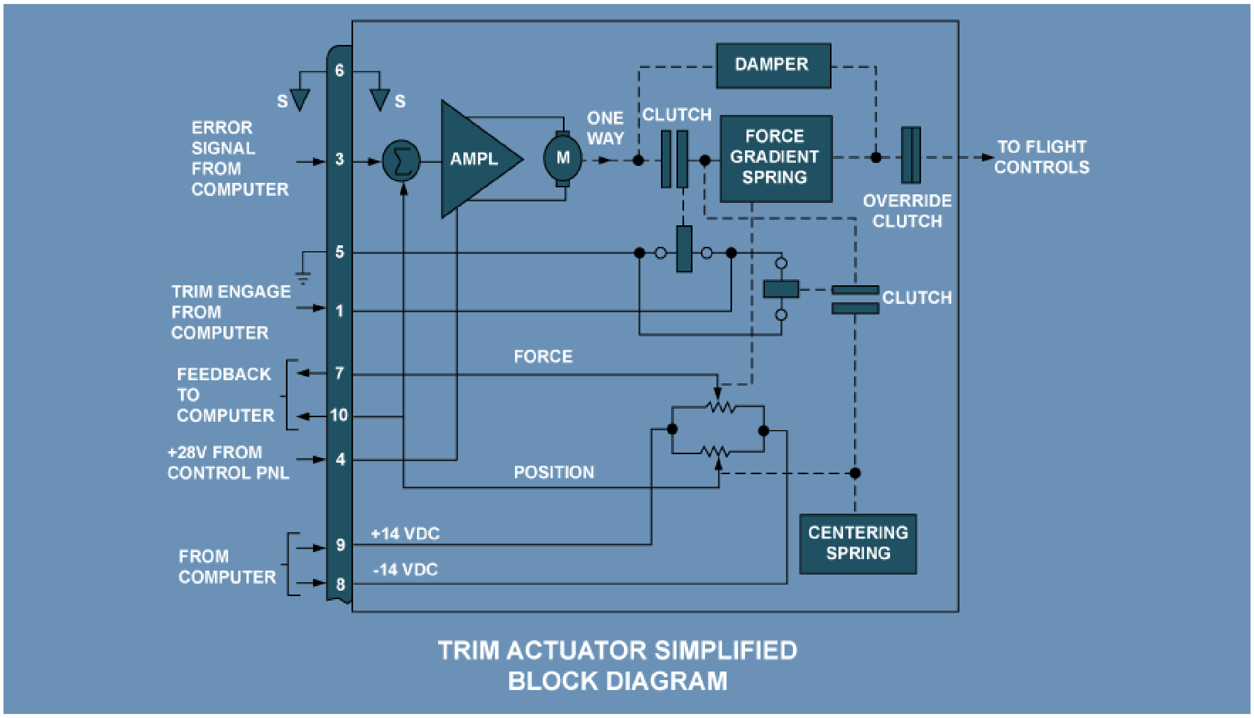
(30) With SAS 1 or SAS 2 disengaged, the gain of the engaged system is doubled to maintain stability control; while its authority remains at 5%.

(31) The stabilator controls/auto flight control panel applies a signal to the SAS amplifier to indicate engagement of the SAS 2 system.

(32) Disengagement of SAS 2 removes the signal from the amplifier, causing the gain of the SAS 1 signals to double.

d. Trim System

Frame #4100 (Trim Actuator/Servo)



(1) Trim Actuator/Servo

(a) The roll and yaw trim actuator/servos are electromechanical actuators, providing flight control force feel, position hold and damping in the yaw axis only.

(b) A damper minimizes oscillations of the flight controls in the yaw axis only, the roll trim actuator/servo damper is disabled.

(c) The drive motor physically moves the flight controls when a error signal from the SAS/FPS computer is applied to the drive motor amplifier.

(d) The force gradient spring provides flight control force feel to the pilot when trim is engaged, and also gives the pilot the authority to override trim while still maintaining trim reference.

(e) The trim actuators incorporate an override slip clutch which allow the pilot to make inputs should the actuator jam.

(f) The override force required to activate the roll trim actuator override clutch is 13 lbs maximum and, 80 lbs for Yaw trim actuator.

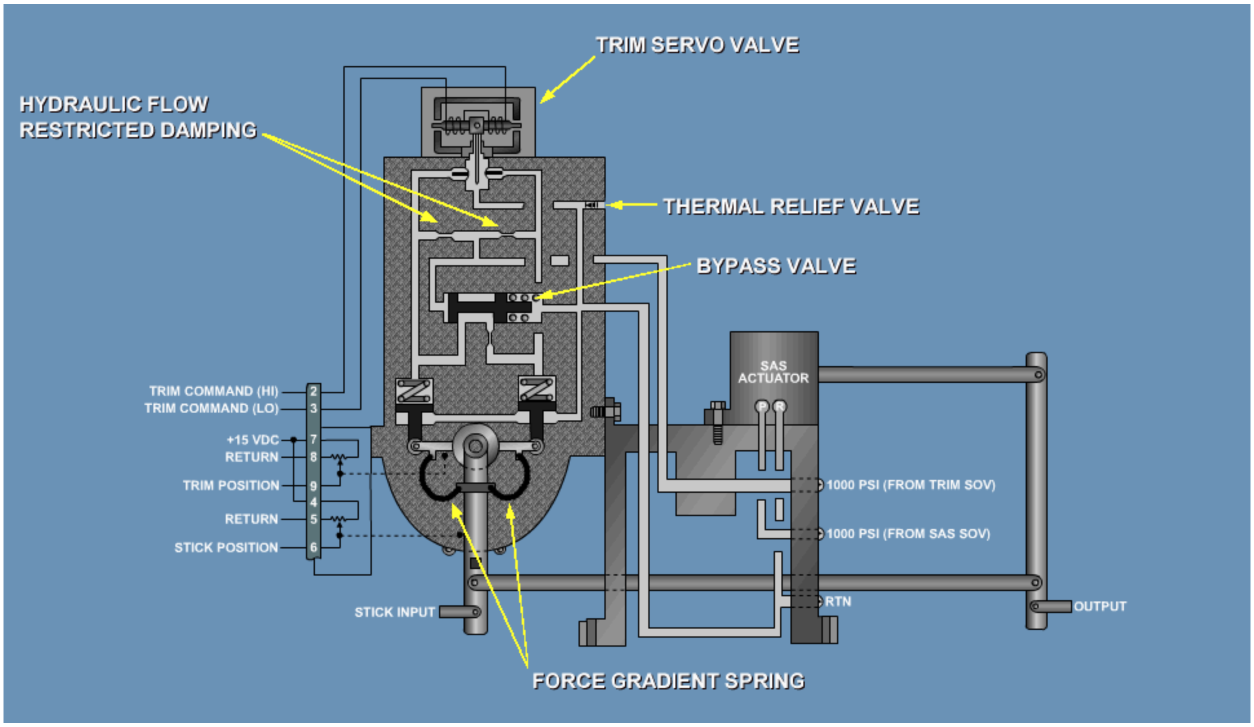
(g) The clutch assembly physically connects the drive motor and position sensing rheostats to the flight controls when trim is engaged.

(h) Position sensing rheostats provide a signal to the SAS/FPS computer and to the drive motor amplifier.

(i) A centering spring recenters the position sensors to a balanced condition, when trim is disengaged, or when either the TRIM REL switches on the cyclic sticks are pressed with trim engaged.

(2) Pitch Trim Assembly

Frame #4115 (Pitch Trim Assembly)

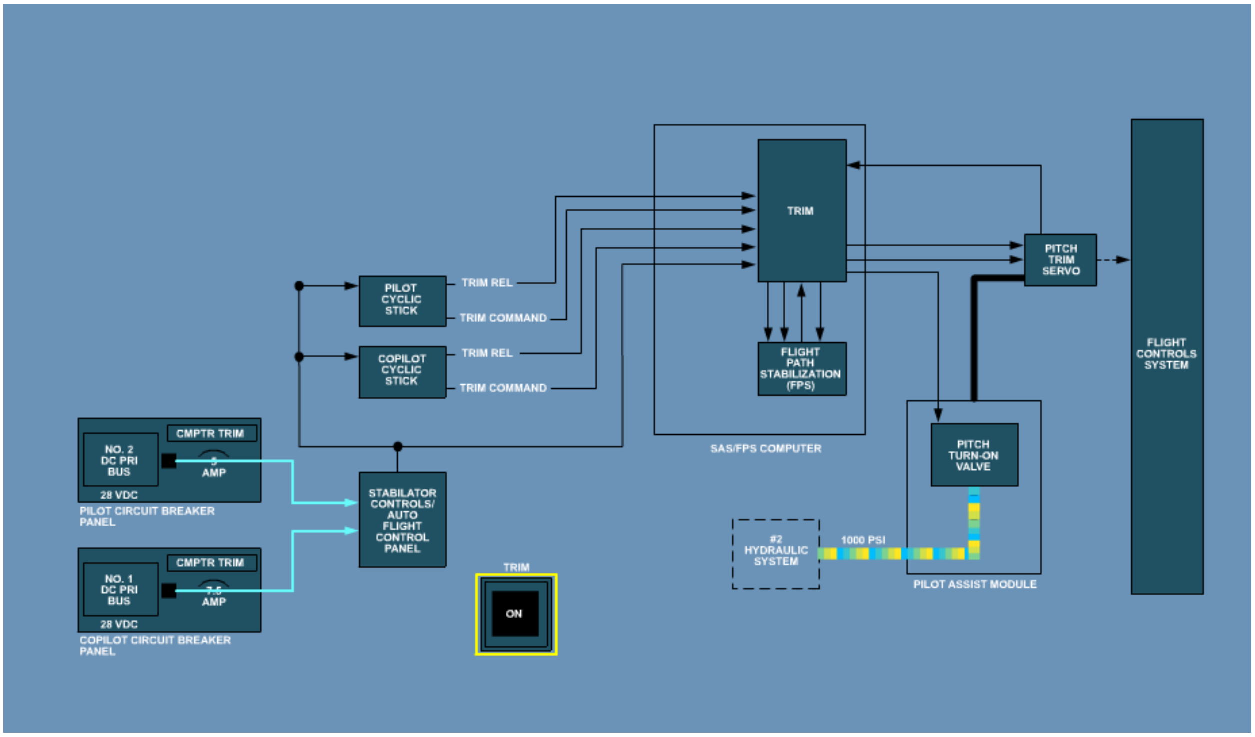


(a) The pitch trim assembly is a hydroelectromechanical actuator that receives 1000 PSI from the pilot assist module.

(b) Hydraulic pressure is supplied only if the Trim is ON and the SAS/FPS computer detects no pitch trim malfunctions.

(3) Pitch Trim Simplified Diagram

Frame #4120 (Pitch Trim Simplified Diagram)



(a) With trim engaged, + 28 V dc is applied to the pilots cyclic stick grips through the TRIM REL switch and STICK TRIM command switches in each grip.

(b) The TRIM REL switch allows the pilots to momentarily disengage pitch and roll cyclic trim to establish a new attitude reference.

(c) With trim engaged, the SAS/FPS computer receives a + 28 V dc signal from the TRIM REL switch.

(d) The computer maintains pitch trim by applying a ground signal to the pitch turn-on on valve.

(e) A trim piston within the servo is held in place by the hydraulic pressure, to establish pitch trim reference, and is connected to the cyclic pitch control through a force gradient spring.

(f) The gradient spring gives the pilots the authority to override trim while still maintaining trim reference.

(g) When the TRIM RELEASE switch on the pilot cyclic stick is pressed, the 28 V dc signal is removed from the computer, which disables the signal to the pitch turn-on valve.

(h) The pitch turn-on valve closes, removing hydraulic pressure from the trim piston.

(i) This action will permit unrestricted cyclic movement to the new reference position.

(j) The STICK TRIM switch on the pilot cyclic stick, gives the pilot another means of selecting a new cyclic trim reference.

(k) The switch provides cyclic trim command signals that result in FWD or AFT movements of the cyclic stick.

(l) The stick command signals are applied to the SAS/FPS computer, which produce drive output voltages.

(m) The pitch drive voltage is applied to a solenoid in the pitch trim servo that controls hydraulic flow to the trim piston.

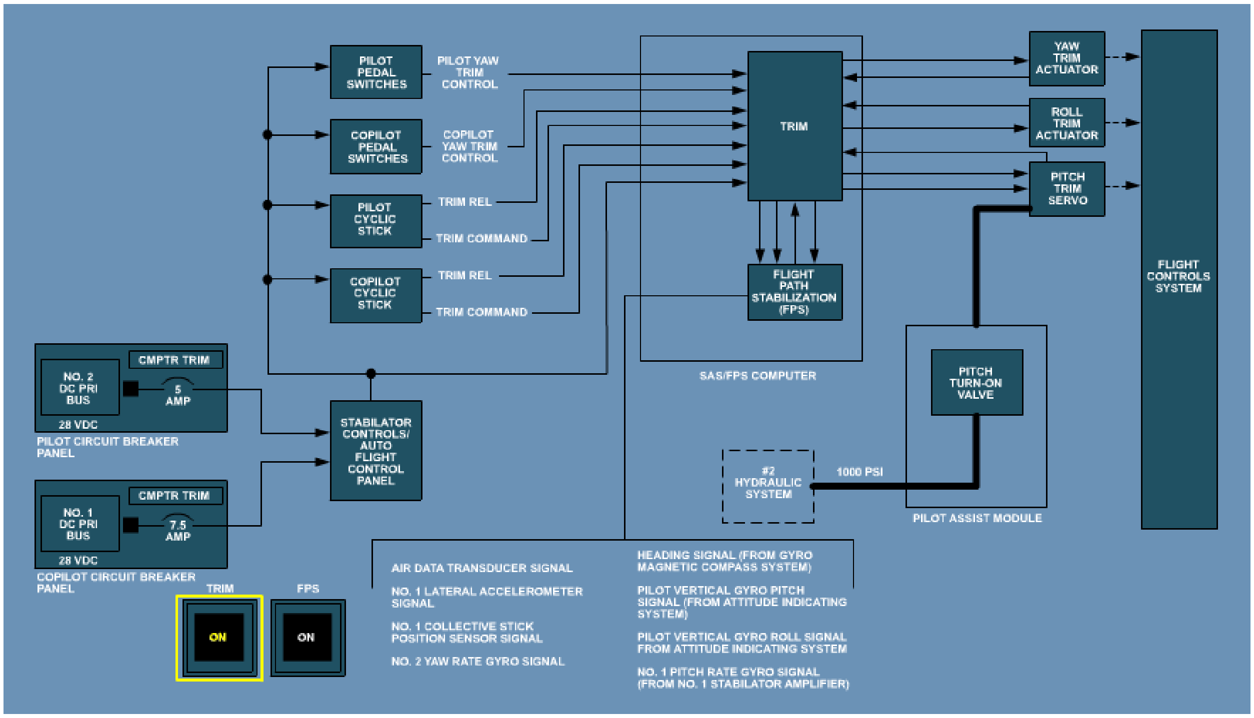
(n) As the piston moves, the mechanical connection through the force gradient spring repositions the cyclic stick.

(o) The piston also moves a potentiometer that develops a signal proportional to trim position.

(p) This signal is fed back to cancel the drive voltage in the computer and stop piston travel when the desired position is reached.

e. Flight Path Stabilization (FPS)

Frame #4020 (Flight Path Stabilization (FPS) FLASH)



(1) The FPS functions below 60 knots maintains helicopter pitch and roll attitudes and heading hold.

(2) Above 60 knots it also includes airspeed hold, and provides a coordinated turn feature.

(3) The FPS function is engaged by first engaging the control panel TRIM switch and then pressing the control panel FPS switch.

(4) When engaged, the switch ON legend is illuminated. With FPS engaged, +28 V dc is fed from the control panel to the SAS/FPS computer.

(5) The computer provides FPS command signals to the trim actuator voltage drivers, which reposition the flight controls through the trim actuators.

(6) The FPS command signals maintain the cruise flight attitude and heading established by the trim reference.

(7) The roll attitude retention function uses the attitude indicating system No. 1 vertical gyro roll signal to sense helicopter roll attitude.

(8) The computer derives a rate signal from the changing proportional amplitude, which is summed with the proportional signal.

(9) The resultant signal is compared with the roll trim position signal and the difference is applied to the trim actuator as a roll FPS command signal.

(10) The pitch attitude/airspeed hold function controls the helicopter pitch attitude necessary to maintain a desired airspeed.

(11) Pitch attitude/airspeed hold function uses the No. 1 vertical gyro pitch signal to sense helicopter pitch attitude and uses the pitch rate signal from the No. 1 stabilator amplifier to sense rate of change in pitch attitude.

(12) The signals are processed together in the computer and added to the No. 1 airspeed signal from the stabilator system airspeed transducer.

(13) The resultant signal is compared with the pitch trim position signal and the difference is applied to the pitch trim servo as a pitch FPS command signal.

(14) The heading hold function maintains helicopter heading in a hover or cruise flight. Below 60 knots, the function is engaged when the pilot's feet are off the pedals.

(15) Above 60 knots, the function is engaged unless a coordinated turn in commanded by the pilot.

(16) The heading hold function uses the compass system heading signal and derives a yaw rate signal from the changing proportional signal.

(17) The rate and proportional heading signals are added to the No. 1 collective stick position sensor signal which compensates for collective to yaw cross feed.

(18) The resultant signal is compared with the yaw trim position sensor signal and the difference is applied to the yaw trim actuator as a yaw FPS command signal.

(19) The coordinated turn function coordinates tail rotor input to the bank angle selected with the cyclic stick.

(20) The function is operational at airspeeds above 60 knots when roll stick input is applied and a bank angle greater than 2° is attained.

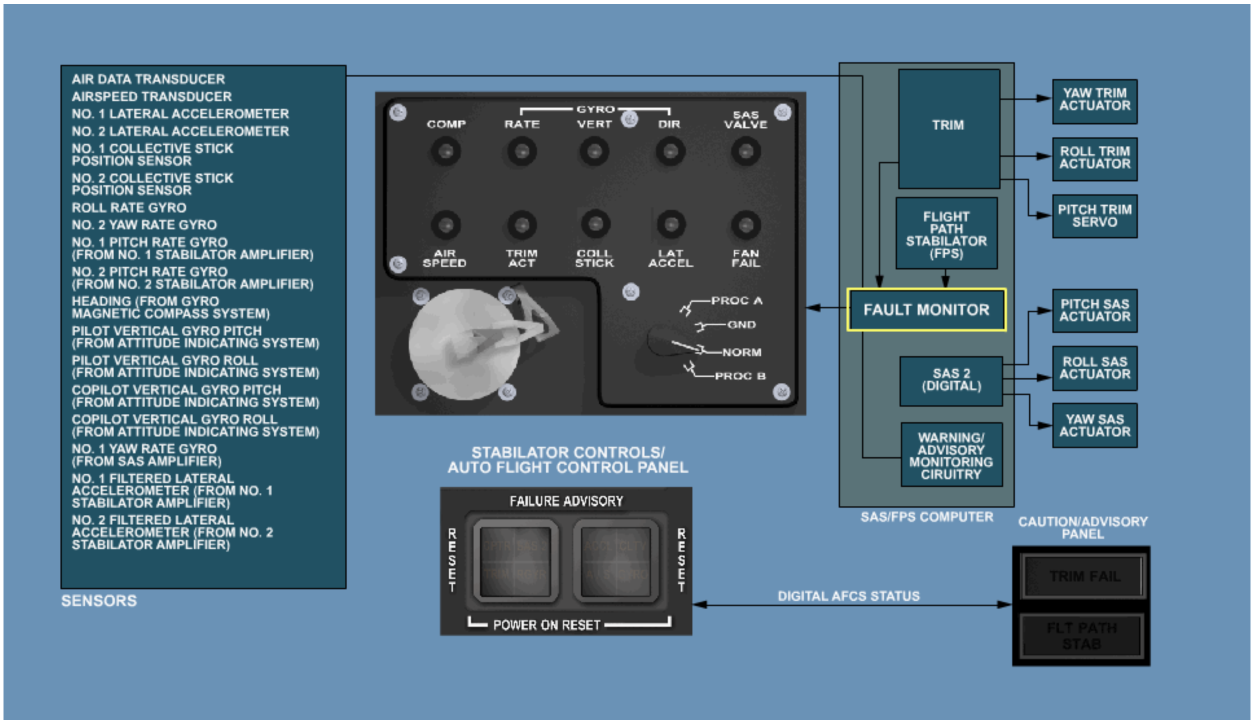
(21) The function uses all the sensor inputs described for heading hold function and adds a roll rate signal, derived from the No. 1 vertical gyro, and the No. 1 lateral accelerometer signal.

(22) The added signals produce a yaw FPS command signal that automatically coordinates the tail rotor input to the turn bank angle.

(23) As the turn is completed, FPS operation automatically returns to the heading hold function.

f. SAS/FPS Computer Failure Monitor

Frame #4300 (SAS/FPS Computer Failure Monitor)



(1) The SAS/FPS computer continuously monitors digital AFCS operation by comparing sensor input signals, testing program functions, checking output signals, and checking actuator reaction to output signals.

(2) Should a fault be detected, the computer automatically disables any function affected and changes a maintenance indicator from black to white on the front panel to identify the source of malfunction.

(3) The computer also provides fail advisory output signals to the control panel FAILURE ADVISORY switches and caution/advisory panel.

(4) The No. 2 pitch and roll gyro signals from the attitude indicating system are applied to the computer for comparison with the No. 1 gyro inputs.

(5) The derived rate signals produced by the computer from the vertical gyro signals are used to compare rate gyro inputs from the roll rate gyro, yaw rate gyro, and No. 2 stabilator amplifier pitch rate gyro.

(6) The No. 2 airspeed signal from the air data transducer in the stabilator system is used to compare the No. 1 airspeed signal.

(7) The No. 2 stabilator amplifier lateral accelerometer signal is used to compare the No. 1 lateral accelerometer signal.

(8) The No. 2 collective stick position sensor, mounted on the right side of the mixing unit, is used to compare No. 1 position sensor signals.

(9) The computer checks SAS valve solenoids by comparing the return current flow from the valve with the output signal. Any difference will indicate an open or shorted valve solenoid.

(10) The computer disables the affected SAS 2 channel (pitch, roll, or yaw) and lights the SAS 2 FAILURE ADVISORY capsule.

(11) The pitch trim servo, yaw trim actuator, and roll trim actuator each contain a position sensor that indicates trim position.

(12) If the sensor signal does not follow the trim drive voltage, a malfunction is indicated.

(13) The computer will disable the affected channel and light the TRIM FAIL and FLT PATH STAB caution/advisory capsules.

i. FPS System/Trim System MTF Checks

(1) Listed is a simplified list of maintenance test flight checks for the FPS/TRIM systems.

(a) HYD leak test (SAS / FPS fault monitoring)

(b) SAS / FPS computer check (Proc A = Pitch Proc B = ROLL / YAW

(c) Trim system check (trim actuator or SAS / FPS computer)

(d) Cyclic force gradient check (trim release buttons, force gradient spring)

(e) Cyclic trim (force gradient spring, centering spring)

(f) Cyclic force (force gradient spring)

(g) Yaw pedal force gradient (micro-switches, trim actuator)

(h) Dampening forces check (trim actuator)

(i) Beep trim (stick trim switch, trim, FPS)

(j) Beep time (trim motor speed, dead spots on potentiometer)

(k) Collective to yaw electronic coupling (#1 collective position transducer, air data transducer, trim, trim card)

(l) FPS heading hold (micro-switches, ASN-43, FPS, trim)

(m) FPS hover checks (ASN-43, #1 vertical gyro, trim)

(n) 120 knots checks (ASN-43, #1 vertical gyro, trim, 60 knots switch, #1 lateral accelerometer)

(o) Beep trim checks (ASN-43, 60 knots switch, #1 lateral accelerometer, #1 vertical gyro> 2 degrees roll)

(p) Attitude/airspeed check (#1 vertical gyro, A/S transducer)

CHECK ON LEARNING

1. How much authority does each SAS system have?

2. The SAS/FPS computer continuously monitors_______

3. Disengagement of either SAS 1 or SAS 2 causes the remaining system output gain to ________, while its authority ____________.

4. The roll attitude hold function is limited to _____ of SAS 2 authority?

SECTION VI. - SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the characteristics of the Digital AFCS System topic.
The key points to remember are:

- The SAS 2 pitch channel uses the pitch rate gyro signal from the No. 2 stabilator to sense the direction and rate of longitudinal helicopter movement.
- The SAS 2 roll channel uses the output of the rate gyro to produce a short-term correction signal.
- It also uses the No. 1 vertical gyro roll signal from the pilots vertical gyro to produce a proportional signal that holds the helicopter in a level roll attitude. The polarity and amplitude of the proportional signal depends on the direction and amount respectively of displacement from a level attitude.
- The proportional signal is added to the rate signal, and the resultant is applied to the roll SAS servo valve.
- The attitude hold function is limited to 1.2% of SAS 2 authority and is disabled at roll attitudes greater than 7 degrees.
- The sensors used by the SAS yaw channel are determined by helicopter airspeed.
- With SAS 1 or SAS 2 disengaged, the gain of the engaged system is doubled to maintain stability control; while its authority remains at 5%.
- The SAS/FPS computer also provides fail advisory output signals to the control panel FAILURE ADVISORY switches and caution/advisory panel.

APPENDIX A

ILLUSTRATION LISTING

1235	Collective Stick Position Transducers
1240	Left Relay Panel
1245	Lateral Accelerometer
1250	Stabilator Amplifier
1252	Stabilator Amplifier Test Points
1255	Pitch Rate Gyros
1260	Position Transmitter Assembly Limit Switch
1265	Stabilator Actuators
1270	Stabilator Attachment Fitting
2005	Stabilator System Components Review
1115	Operation Menu
2012	Auto Mode Requirements
2015	Stabilator Scaling Amplifier Circuit
2020	Automatic Mode Flash
2025	Stabilator Shutdown Threshold
2030	Stabilator System Test (Flash)
2035	Stabilator Test Panel (Flash)
2040	Manual Mode (Flash)
2055	Stabilator Checks2
3005	SAS 1 Component Refresher
3010	SAS 1 System
4005	Digital AFCS Component Review
4010	Transmission/Upper-Deck Component Review
4020	Flight Path Stabilization (FPS) (Flash)
4100	Trim Actuator/Servo (Flash)
4115	Pitch Trim Assembly
4120	Pitch Trim Simplified Diagram (Flash)
4200	SAS 2 Schematic
4210	SAS 1/SAS 2 Interface
4300	SAS/FPS Computer Failure Monitor
4310	Failure Monitor Malfunction Logic

APPENDIX B

TEST AND TEST SOLUTIONS

1. This appendix is only used when the test and solutions are internal to the POI file.

2. When the test and solutions are internal to the POI file, then the POI file becomes a FOR OFFICIAL USE ONLY document.