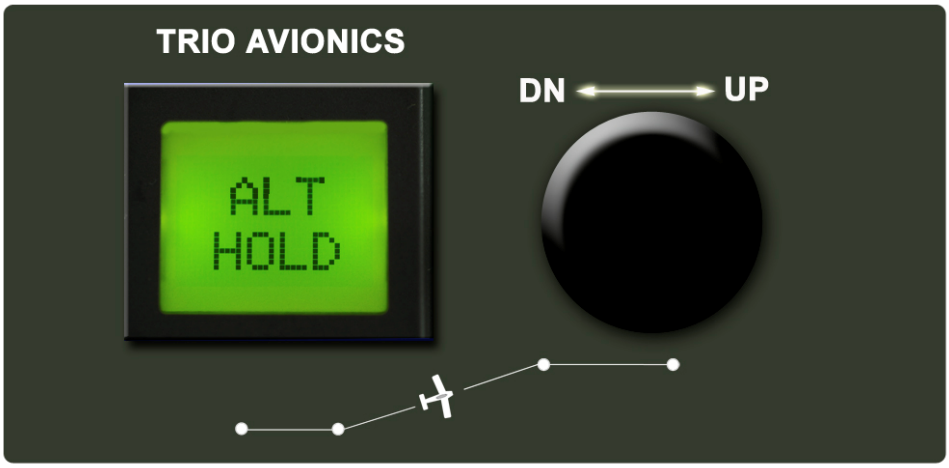
EZ-1 Altitude Hold



Operation and Installation Manual

Trio Avionics Corporation

Rev 1.4

Notice and Warnings

Warning: Any failure to comply with the following warnings can lead to property damage, and serious injury including death.

Although Trio Avionics has taken reasonable steps to test its product, the final determination of safe operation lies with you, the installer and pilot. Your workmanship in installing, cabling, and testing the Altitude Hold system in your airplane is critical to safety. If you are not the original builder of your aircraft, and do not hold a valid "Repairman's Certificate" for your aircraft, you must have the installation done by a qualified A&P aircraft mechanic or the original builder. You must comply with all current FAA regulations regarding installation of this device in your airplane.

This product is to be used on homebuilt, experimental aircraft only. It is not approved for, nor is it legal to install it in, certified aircraft. It is not approved by any governmental or non-governmental agency.

Prior to installing or flying this altitude hold system, read the manual completely. If you have any questions about the installation or operation of the system, **STOP** and then call or email Trio Avionics for clarification.

The servo that is a part of this altitude hold system is attached directly to your elevator control system. It is possible to install or adjust it in a manner that may result in improper or unexpected elevator movement that could result in dangerous aircraft maneuvers. Install it only after you have read and understand the installation instructions. You must thoroughly inspect and test your installation prior to flight. Mistakes in any modification to your aircraft can be life threatening!

Each homebuilt aircraft is individual in its construction, maintenance and flying characteristics. Therefore, while Trio Avionics has tested the product in a variety of aircraft, we do not represent or warrant that it is appropriate or suitable for use in your particular aircraft. Only you can make that determination and ultimately only you are responsible for its safe installation and use.

This product is designed for use as an en route navigation aid only, and only at safe altitudes in unobstructed airspace. It must not be relied upon for any other purpose. It is not to be used for flight in instrument meteorological conditions (IFR), or approaches into airports in either IFR or visual (VFR) conditions. Power to the servo must be turned "off" for takeoffs and landings.

In operation, this product relies upon data provided by solid state sensors, gyros and electronic components. Always keep in mind that such systems should never be thought of as totally reliable. They may be disrupted by electromagnetic interference, close proximity of transmitting antennas and cables, and other problems.

When flying an aircraft with this, or any, altitude hold system enabled, you must be constantly vigilant for any sign of improper operation of the system. When there is even a suspicion that the altitude hold system is not operating properly, you must immediately disable the altitude hold system by any of the various methods detailed in this manual. Do not fly the altitude hold system without incorporating the remote servo disconnect switch that is described in this manual.

There may be a tendency to concentrate on the instrument display when test flying this or any other new system in your aircraft. Do not allow it to distract you from the need to "see and avoid" other aircraft.

The safe practice of aviation demands the consistent exercise of pilot skill, knowledge of airmanship and weather, judgment and focused attention at a level which is appropriate to the demands of each individual situation. Pilots who do not possess or exercise the required knowledge, skills and judgment are frequently injured or killed. Therefore, although an altitude hold system can serve as a useful navigation aid, no altitude hold system can be relied upon and you must be at full attention at all times while flying any aircraft.

If you do not agree to comply with any of the warnings or notices above, do not install or fly this altitude hold system in your aircraft. Call Trio Avionics for a Return Material Authorization (RMA) and return the unused system for a full refund.

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EZ-1 Altitude Hold

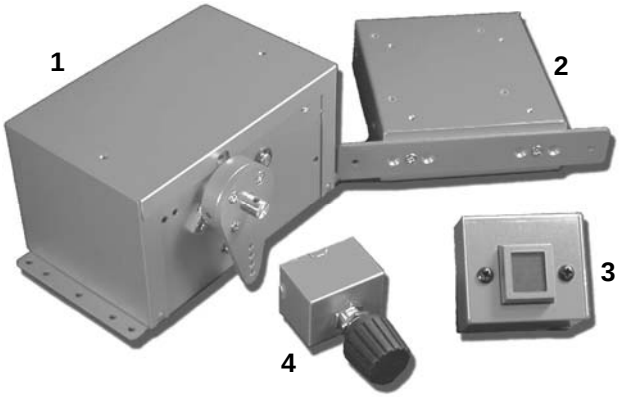
1.0 Introduction

Congratulations on choosing the EZ-1 altitude hold system. It is designed to precisely maintain a desired pressure altitude for your experimental aircraft up to an altitude of 20,000 feet. In smooth air it will easily hold the aircraft altitude to within +/- 20 feet (generally less). In turbulent air or moderate rate turns it will hold to within +/- 50 feet.

While the EZ-1 is inherently simple to use, this manual will serve as a guide to understanding its basic functions and employing its many features. **Operation is as simple as pressing the "ALT HOLD" button.** This causes the aircraft to maintain the selected altitude. The following sections illustrate the built in safety measures, messages and the many features available in your new system.

2.0 General Information

The EZ-1 altitude hold system is comprised of 4 major hardware elements:



1 Elevator Servo
2 Electronics Module
3 LCD push button switch
4 Rotary encoder control

In addition, an external Sonalert or other warning device may be connected to provide an audible warning prior to system disconnect. (Normally the audio tone may be made available via aircraft intercom system). An auxiliary small remote push button (momentary – normally open) switch mounted to the stick or yoke will allow access to the many additional features of this system.

3.0 Operation

When power is applied, the amber **SYSTEM TEST** message will be displayed for approximately 5 seconds. After this stabilization period the unit will become fully functional. The LCD switch will display a green **READY** message. The altitude hold function is activated by pressing the LCD switch which will then annunciate the hold condition with a green **ALT HOLD** message on the LCD display. (At this time servo activation should be detected by resistance to manual yoke or stick movement forward or backward)

To disconnect the EZ-1 system servo activation either the **REMOTE AUTOPILOT DISCONNECT** switch or the **LCD SWITCH** may be momentarily pressed.

During normal operation in the altitude hold mode the **ENCODER** knob may be used to dial in very fine corrections to the engaged altitude. Rotating the knob clockwise will cause an altitude increase, rotating the knob counterclockwise will result in an altitude decrease.

In addition to the servo disconnect function the **REMOTE AUTOPILOT DISCONNECT** switch can be used to "fly to" another altitude. This is accomplished by pressing **and holding** the REMOTE **AUTOPILOT DISCONNECT** switch for a period of more than three seconds. The servo will immediately disengage so the airplane can be flown to a different altitude and will rearm after the three second delay period. While in the armed mode the LCD switch will flash the green backlight and will display **ALT HOLD**. Releasing the remote disconnect switch (after the 3 second interval) will engage the servo and cause the LCD switch to go to a solid green displaying the **ALT HOLD** message

3.1 Startup

It is strongly recommended that a 3 to 5 amp switch or circuit breaker be used to power the **EZ-1** system. This switch or circuit breaker will provide absolute emergency disconnect of the altitude hold servo should all other disconnect measures fail. Once the aircraft engine is started, part of the pre-taxi checklist should be to apply power to the EZ-1 system by engaging the switch or circuit breaker. **Power should be applied as soon as possible after engine start to ensure the inertial components within the system are stabilized prior to takeoff.**

After power is applied, the system will undergo a brief startup sequence which will last approximately 5 seconds. During this time the amber **SYSTEM TEST** message will be displayed. After this short period the unit will become fully functional and the LCD switch will display a green **READY** message.

3.2 "ALT HOLD" Mode

The altitude hold function is activated by momentarily pressing the LCD switch which will then annunciate the altitude hold condition with a green **ALT HOLD** message on the LCD display. (During pre-taxi checks, servo activation can be detected by resistance to manual yoke or stick movement forward or backward).

IMPORTANT: Prior to taxi, momentarily press the remote disconnect switch to disengage the servo. The LCD switch will then display the **READY** message. A pre-flight checklist item should be created to ensure the altitude hold system is disengaged (in the **READY** mode)

Once the aircraft is in flight, and the desired altitude has been reached, the aircraft should be trimmed for stable, level flight. The pilot may then simply press the LCD switch and the EZ 1 will enter the altitude hold mode and the LCD switch will display **ALT HOLD** while it is employed. The servo will engage the elevator system and control the elevators to maintain the desired altitude.

To disconnect the EZ-1, the pilot may momentarily press either the LCD switch or the **REMOTE AUTOPILOT DISCONNECT** switch on the stick or yoke. The system will then immediately release the elevators from servo control and enter the **READY** mode.

3.2.1 Fine Adjustments to Altitude - While flying with the **ALT HOLD** engaged, the **ENCODER** knob may be used to dial in very fine corrections to the engaged altitude. Rotating the knob clockwise will cause an altitude increase (and cause the LCD to indicate "ALT UP ADJUST"), while rotating the knob counterclockwise will result in an altitude decrease and corresponding display. Each "click" of the knob will change the altitude by approximately 5 feet, up or down, depending on the direction of rotation. When the altitude change is completed, the green Alt Hold display will appear. Alternatively, the **encoder** knob may be pressed at any time to stop the adjust feature.

3.2.2 ADJUST TRIM Annunciator – As the flight progresses the aircraft may require occasional trim changes as the fuel burn lightens the aircraft, or if the throttle setting is changed. The servo will hold the proper altitude in all but extreme out-of-trim conditions, but it is prudent to keep the aircraft properly trimmed to avoid sudden excursions when the servo is disengaged.

The **EZ-1** will sense when the aircraft is out of trim. If the out-of-trim condition is minor it will not alert the pilot. However, when the out-of-trim forces on the servo exceed a predetermined amount, it will present a message (flashing up or down arrows) to the pilot advising that the aircraft trim should be adjusted. The arrows on the display indicate the required direction of trim adjustment. The altitude will be maintained even though this alert is present.

Once proper trim has been reestablished the **ADJUST TRIM** arrows will be removed, and the normal **ALT HOLD** message will return. Pressing the **ENCODER** switch while the **ADJ TRIM** arrows are present will erase the message, remove the trim correction provided by the system and replace it with the **ALT HOLD** message. If the out of trim condition remains after the message has been cleared the message will likely return in a short period of time.

Probably the quickest way to eliminate the out-of-trim condition is to momentarily disconnect the **ALT HOLD** function by pressing the **LCD switch**, re-trim the aircraft for level flight, and then reengage the **ALT HOLD**.

NOTE – If the **ADJ TRIM** arrows appear on the LCD, but when the **ALT HOLD** is released there is very little trim correction required to the aircraft, the **SYSTEM GAIN** setting is probably too low, not allowing the system to properly control the aircraft. See section 6.0 for proper adjustment of the **SYSTEM GAIN** setting,

If the pilot wishes to re-trim the aircraft without disconnecting the **ALT HOLD**, trim adjustments should be made in small increments. When each adjustment is made, the pilot should wait for approximately 10 – 15 seconds to allow the system to sense the change. If the **ADJUST TRIM** message remains, continue further adjustments until the **ALT HOLD** message returns.

3.3 Pilot Command Steering (PCS) Mode

In addition to the servo disconnect function, the **REMOTE DISCONNECT** switch can be used to “fly to” another altitude. This is accomplished by pressing and holding the **REMOTE DISCONNECT** switch for a period of more than three seconds. The servo will immediately disengage so the airplane can be flown to a different altitude manually and will “re-arm” after the three second interval. While in the “armed” mode the **LCD switch** will flash a green backlight and will display **ALT HOLD**. Releasing the remote disconnect switch will engage the servo and cause the **LCD switch** to present a solid green color while displaying the **ALT HOLD** message. The aircraft will then hold the selected altitude.

3.4 Brightness, Contrast, Gain and Servo Deadband settings

The **BRIGHTNESS**, **CONTRAST, GAIN and SERVO DEADBAND** settings are adjustable with the Altitude Hold system in the operational mode. This menu mode is entered from either the **READY** mode or the **ALT HOLD** mode by **pressing in and holding** the encoder switch knob for at least 2 seconds.

To activate the mode and set the **GAIN**, **BRIGHTNESS**, **CONTRAST** or **SERVO DEADBAND** settings, perform the following steps when either **READY** or **ALT HOLD** message is displayed on the LCD switch:

1. Press and hold the encoder switch knob until the **GAIN SET** message appears on the **LCD switch**

2. Press (click) the encoder switch knob repeatedly until the desired selection is displayed.

3. Rotate the encoder switch knob to change the setting.

The **GAIN** setting controls the response characteristics of the system. The proper adjustment of this parameter is fully discussed in paragraph **6.0.**

The **BRIGHTNESS** setting controls the illumination level of the LCD Background. This setting is best done in subdued light.

The **CONTRAST** adjustment will allow setting the optimum contrast for the pilots viewing angle.

The **SERVO DEADBAND** setting controls the “deadband” width of the servo. The proper adjustment of this parameter is fully discussed in paragraph **6.0.**

4. Press and hold the encoder switch knob for 3 seconds to exit back to **READY** or **ALT HOLD** display mode.

NOTE: Even when the Contrast / Brightness / Gain / or Servo Deadband is selected, the LCD switch or the **REMOTE DISCONNECT** switch can be pressed to disengage the servo and return to the **READY** mode. Likewise, if the selection was entered from the **READY** mode, pressing the LCD switch will cancel the selection and activate the **ALT HOLD** mode

3.5 Safety Warning Features

3.5.1 Audible Warning

Whenever the servo disconnects from the elevator control system, an audio alarm is sounded. This intermittent tone (beeping) may be routed into the aircraft audio system, as shown on the wiring diagram on page 19. Alternatively, an intermittent DC voltage is also provided on the connector to allow use of an external warning device, such as a Sonalert[tm] or other warning instrument.

3.5.2 G Force Limit

When giving elevator control over to a servo, the pilot must be constantly vigilant to assure that any unexpected system activity, such as that caused by extreme turbulence or meteorological wave activity, cannot impose excessive acceleration forces to the aircraft. To assist in this endeavor, the **EZ-1** incorporates an accelerometer system that continually monitors the G forces being experienced by the aircraft.

In the event the aircraft experiences abnormal G forces, the **EZ-1** system is designed to automatically disconnect from the control system before structural damage can occur. The software is designed to detect acceleration (G) forces that can cause structural damage due to system activity (or pilot override action). The system will monitor, *but not react to*, accelerations due to moderate turbulence. However, it is possible the system may automatically disconnect in high end moderate or severe turbulence. The pilot is always cautioned to use proper judgment as to whether to engage the **EZ-1** system in these types of conditions. The pilot should always follow the aircraft designer's recommendations with regard to autopilot engagement, maneuvering speed limitations, etc.

System Response – When the **EZ-1** system detects an excessive G force condition it will immediately issue an audible alarm and disconnect the servo from the control system. The LCD switch will illuminate red while displaying "**G FORCE LIMIT**".

Pilot Action – Determine the cause of the excessive G force problem. If the disconnect was due to turbulence or pilot action, the alarm may be cleared by pressing the LCD switch, which will put the system back in the **READY** condition. Altitude hold may then be re-engaged by pressing the LCD switch. Pilot judgment should be exercised in accordance with the airframe designer's limitation regarding use of an autopilot system in turbulent conditions. If an **EZ-1** system control problem is suspected, turn off power to the system and contact Trio Avionics for direction before further use.

3.5.3 Servo Clutch Slip

The **EZ** altitude hold incorporates an important special safety feature: a clutch within the servo that can be overridden when active by moderate manual stick or yoke pressure. Sensors are provided in the servo to detect slippage of the mechanical clutch assembly.

The message "**SERVO CLTCH SLIP**" will appear as a flashing amber message if the condition is sensed.

The clutch adjustment should be set during installation so that the system can drive the elevator control system under normal conditions but be easily overridden by a manual pilot input. Pilot override will force the clutch to slip, allowing the pilot to take positive control away from the **EZ-1** system in emergency situations such as unexpected traffic. On the other hand, a clutch slip message that appears for no apparent reason is probably due to the clutch not being adjusted properly, thereby not allowing the control system to be driven correctly.

System Response – the message "**CLUTCH SLIP**" will flash with amber illumination. The message is advisory in nature and will not cause a servo disconnect. In the event the clutch slip persists for **eight** continuous seconds the **CLUTCH SLIP** message will be a solid red alarm and the servo power will be disconnected.

Pilot Action – the advisory message can be removed from the display by pressing the encoder switch. If the alarm message (red) occurs, the **LCD** switch must be pressed to return the **SYSTEM** to the **READY** mode. If either message occurs under conditions other than a manual servo override the clutch adjustment should be checked when possible to ensure it is tight enough to drive the control system under normal conditions including light to moderate turbulence and normal out of trim conditions. However, you must assure that it is set loose enough that the pilot can easily overcome it in an emergency.

3.5.4 Servo CW (or CCW) Limit

This red message indicates the servo crank arm has been moved to a clockwise or counterclockwise position outside of its normal range of operation. This error will result in an immediate servo disconnect. The cause of this error is most likely a manual system override by the pilot. Another less probable cause would be a servo system runaway or not accomplishing the alignment procedures called out in paragraph 6.6.

System response – immediate servo disconnect and servo power down. Red **SERVO CW (or CCW) LIMIT** message displayed.

Pilot Action – Determine the cause of the **SERVO CW (or CCW) LIMIT** message. If due to pilot manual override the system may be reset by pressing the LCD switch which will return the system to the **READY** mode. If the cause of the limit alarm is unknown, turn off power to the system and contact Trio Avionics.

3.5.4 Servo Fault

This red message can be due to several factors based on sensors within the servo and will always cause an immediate disconnect and power down of the servo.

System Response - In all cases the servo will be immediately disconnected from the system, servo power will be automatically removed and a red error message will be displayed

Pilot Action - If the **SERVO FAULT** closely followed an extreme out of trim condition, **CLUTCH SLIP** or **G FORCE** LIMIT alarm , press LCD switch and continue normal operation. If the cause is unknown, or occurs in conditions other than described above, perform ground tests of the system paying particular attention to the wiring from the servo to the electronics module and the mechanical linkage. If the problem persists, contact Trio Avionics for assistance.

4.0 System Safety Features

The altitude hold system incorporates many safety features to ensure the system cannot force the airplane into an un-commanded, unsafe flight regime. The following items are implemented to ensure flight safety.

4.1 Aircraft G-load sensing. The AH module contains an accelerometer interfaced to the main processor that is used to detect unusual positive or negative flight loads. Software algorithms prevent unnecessary detection due to turbulence, but allow shutdown of the servo if the flight loads exceed preset g-force limits. The intent of this implementation is to prevent aircraft structural failure caused by an un-commanded excursion of the servo or trim actuators. The fault condition is annunciated on the LCD switch with the G FORCE LIMIT message

4.2 Servo Electronics monitoring. The servo and trim motor drive circuits are instrumented and monitored by the servo main processor (SMP). The SMP commands the magnitude and direction of the servo motor drive output. Any error in the commanded state of these signals is reported back to the AH module via a digital data link and results in a **SERVO FAULT** message on the LCD.

4.3 Clutch Slip Detection. Circuitry and software is provided that detects any slipping of the safety clutch in the servo. Normally, this condition would only exist in the event the pilot manually forced the control system into a position that exceeded the commanded drive position of the servo. This event is reported to the AH module for resolution. The amber **CLUTCH SLIP** message is displayed for a momentary slip condition. A persistent clutch slip condition will result in a red flashing **CLUTCH SLIP** message and a servo disconnect.

4.4 Rotation Limit Detection. Under normal conditions the servo arm moves less than 20 degrees in either direction from the neutral (servo zero) position. If, for any reason (commanded, un-commanded or pilot manual override), the crank arm transitions approximately + / - 10 degrees outside of this range servo power is disconnected and an error message (CW or CCW LIMIT) is displayed.

4.5 Supervisory processor monitoring. The Servo Main Processor (SMP) is continuously monitored by an independent supervisory processor to ensure it is executing its program as designed. This is implemented via a "heartbeat" signal from the SMP each 10 milliseconds. If for any reason the processor does not provide a "heartbeat" signal to the supervisory processor for a period of 65 milliseconds, the supervisory processor will unilaterally cut power to the safety disconnect solenoid and the trim and servo motor drive circuits. The supervisory processor can only be reset by a power interruption from the AH module. In the event the SMP is still in operation it is designed to monitor the supervisory processor for shutdown, and if detected, it will report this to the AH module. The problem will be reported to the pilot with the red **SERVO FAULT** message being displayed on the LCD switch

4.6 Servo / Trim Driver Chip Fault Detection. The integrated circuits used to drive the servo and trim motors are internally equipped to detect and report to the SMP a variety of fault conditions including:

- High side (supply side) short to ground (low side)
- Low side short to high side
- Under voltage lockout
- Over temperature shutdown

When any of these faults are detected a red **SERVO FAULT** message is displayed

4.7 Disconnect Solenoid. The servo contains a solenoid that allows a complete disconnect of the servo gear train whenever power is removed from the solenoid. Power can be removed under program control of the Servo Main Processor (SMP), the supervisory processor or whenever power is interrupted by the Electronics Module.

4.8 SMP and Supervisory Processor Watchdog Interrupts. Both the SMP and Electronics Module processors have built in peripherals for detecting an improper cycle of the software program. If either of these processors enter this condition a watchdog interrupt will occur which will automatically reset the processor software. This condition is conveyed to the pilot with the red **SERVO FAULT** or the amber SYSTEM TEST message displayed on the LCD switch.

5.0 Installing the Altitude Hold Control Module

The control module is embossed with lettering indicating **TOP** and **RIGHT** (looking forward). It is important to install this module in this orientation because the gyro uses this orientation for pitch recognition. Although the controller may be installed at any convenient place and need not be in the panel or close to it, it must be installed in its proper orientation. Each face of the module has tapped holes that allow the long rectangular mounting plate to be attached to any side of the unit. This will allow for maximum flexibility in locating and mounting it in the aircraft.

A static port is provided to allow the control module to access an accurate pressure source. While it is possible to operate the altitude hold system with the port open to cockpit pressure, it is highly recommended that it be connected to the aircraft static pressure system or an independent static port for most reliable operation.

6.0 Servo Installation Setup

The servo unit incorporates important safety features:

- The internal gears are pulled into the engaged position by an electric solenoid. When the gears are not engaged, the output crank arm rotates freely and the elevator controls can be operated normally without friction. When the servo is engaged, the solenoid pulls the gears into place so the servo has control of the elevators. Disengaging the servo allows free movement of the elevator controls.

- The servo is engaged and disengaged by pressing the **READY** button on the LCD push switch. The button will change to **ALT HOLD** when the servo is engaged. There is also a recommended remote **SERVO DISCONNECT** switch on the control stick (or other remote location). Installation of a remote switch is highly recommended, as it allows an immediate way to disengage the servo - even in heavy turbulence, when it may be difficult to operate the **LCD button**. In addition, such a switch will allow for the **PILOT COMMAND STEERING** feature (Section 3.3).

- The servo also employs a clutch, which allows the pilot to override the servo by applying moderate force to the control stick. Even though the solenoid will hold the gears in place, the clutch will then slip and allow the control surfaces to move. In the event of strong turbulence, or an altitude anomaly, the pilot can thus override the servo to control the airplane. In such an instance, the servo should be disengaged as soon as possible.

NOTE: The clutch function does not rely on a shear pin failure mechanism as is employed on some other popular autopilot servos. Activation of the "clutch" function in no way damages the servo drive system although prolonged operation in this condition should be avoided.

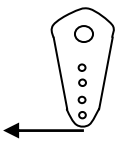
6.1 Installing the Servo

Begin by looking for a point on your elevator bell crank, control pushrod or cable where pushing or pulling the elevator control linkage a distance of 1.5 to 2.4 inches will do the job. Then find a place to mount the servo nearby to accomplish this by means of the pushrod. You will mount the servo and pushrod so that the elevator is in a neutral position when the servo crank arm is at mid position. That's it, aside from carefully checking that **the required range of elevator movement is available within the limits of the servo travel range, and that no "over center" condition can exist.**

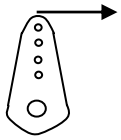
The servo crank arm uses a pushrod terminated by rod end bearings to link the servo arm to the aircraft elevator control system. The pushrod provided in the installation kit should be trimmed to the correct length for your particular installation. The servo should be mounted on a solid platform that will not buckle or "oilcan" and attached to a firm existing support. It is recommended that the servo platform not be mounted to the aircraft "skin" without a doubler or some other additional support. Rigidity of the servo mount is critical to proper servo operation. If you do not have the experience required to fabricate the required bracket please contact Trio Avionics for guidance.

In your installation, it may be more convenient to rotate the crank arm to a new orientation that will give a neutral (servo center position) at +/- 90 degrees or 180 degrees from that as supplied from the factory. The servo crank arm is secured to a flange by four machine screws that can be removed for indexing the crank arm in 90 degree increments.

If the screws need to be removed to reposition the crank arm, heat must be applied to them to facilitate removal as they are secured by a Loctite™ compound from the factory. ***Likewise, after repositioning, Loctite™ Number 222 must be reapplied (very sparingly) to prevent loosening of the screws***



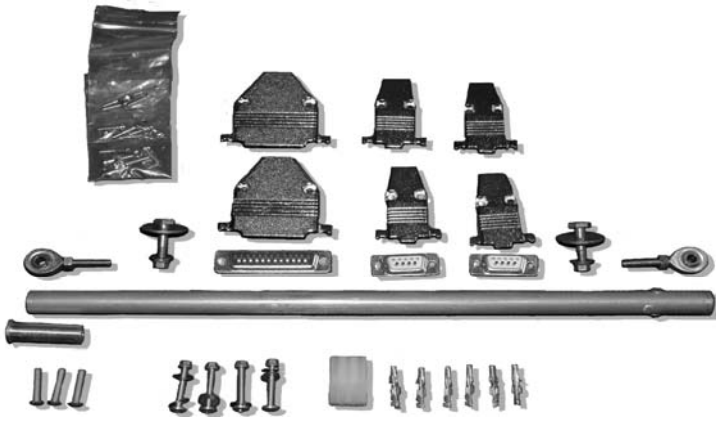
Note: It is important to assure that the proper direction of travel is preserved when modifying the crank arm orientation. Changing the crank arm mounting by 180 degrees will essentially reverse the direction of travel for the servo arm. In such a case the EZ1 must be programmed to reverse the drive signal. In the event unusual pitch changes occur in the first flight, the first check on the ground should be to be certain the servo direction of travel is correct.



Choose an operating radius on the servo crank arm that allows full elevator movement (elevator stop to elevator stop) without driving the servo crank arm into its limits. Most aircraft get best performance in the outermost hole.

6.2 Servo Mounting Hardware

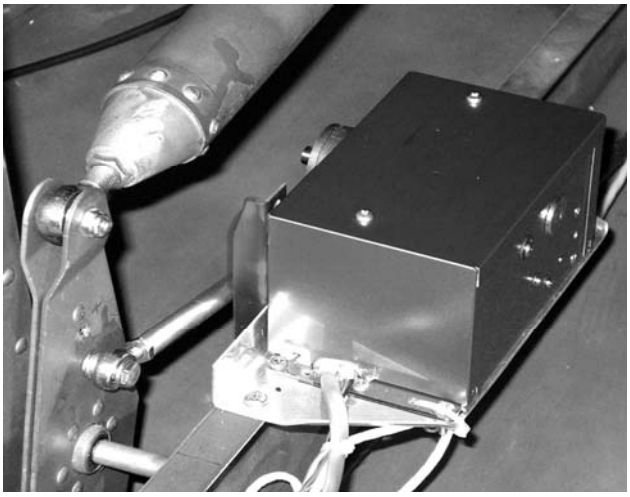
Shown below is the provided electrical and mechanical installation kit. A pushrod is provided, along with two rod end bearings. Typically, one of these connects to the servo crank arm and the other is connected to the elevator bell crank. When the servo is connected to the elevator control system it should be installed so that the servo crank arm is at a right angle to the control rod. This mechanically centers the servo mechanism to the control system so that there is *equal displacement in either direction* when the servo is actuated. Fine zeroing checks conducted after the installation is complete will verify proper positioning.



6.3 Selecting a Site for the Servo

For most aircraft, it's relatively easy to find a suitable site for locating the crank arm servo. The length of the pushrod and, to some extent, the angle it makes with the driven element are user selectable.

The rod end bearing allows some misalignment, usually about 8 degrees, between the servo pushrod and the plane of rotation of the crank arm. This limit on angular displacement often determines the minimum pushrod length. Any side-to-side movement must not jam the rod end bearing. A suitable hard point must be found, or built, for mounting the servo. The mounting place needs to be as accessible as possible, and there must be a means of linking to the elevator control system.



An RV-6 Installation

Note: A longer elevator crank radius dictates a correspondingly longer radius at the drive end. **The elevators must travel from elevator stop to elevator stop within the range of movement allowed by the servo stops** which limit crank arm rotation.

When the above conditions are met, the system usually performs best when the pushrod is attached to the outermost hole in the servo crank arm. If your aircraft employs an elevator bell crank, you should ideally attach the pushrod to the bell crank at a distance from its pivot point equal to that of the servo crank arm radius (distance from crank arm pivot point to pushrod attach point).

Again, never allow the servo to limit elevator travel.

The mounting place must be strong and rigid – conceivably a lateral force of up to five pounds could be encountered. If, for example, you need to mount the servo on the skin of an airplane, it will be necessary to use additional bracing or a "doubler" to provide appropriate rigidity. You do not want the push-pull of the servo to fatigue the metal that holds it.

When mounting the servo, be careful not to drill mounting holes into critical load bearing members. It may be best to construct a mounting plate, place and bond machine screws so that they will interface with the case mounting holes, and then secure the assembly into place. For a composite aircraft installation, the bottom of the plate (shown above) should be floxed and the holes in the plate filled with flox before applying fiberglass layers over it to secure it to the fiberglass structure.

NOTE - It is important that the servo mounting plate surface be flat and smooth. If it is not, this can distort the servo frame when the servo is secured to the mounting plate.

Usually the servo pushrod will terminate on a control pushrod or a bell crank. If you are connecting to a pushrod **care should be taken to keep the pushrod from being free to rotate.** (To repeat, the pushrod should **NOT** rotate.) The reasoning for this is that as the

pushrod rotates there is “lost motion” in the system, i.e., movement of the crank arm does not result in movement of the control system.

The control movements are so small that it takes very little slop in the system to make the airplane not track properly.

It will simplify installation adjustments if there is enough overhead clearance to allow removal and replacement of the servo lid with the servo remaining in place (for instance, you will possibly want to adjust the slip clutch). The servo lid is secured by two screws on the top of the servo.

6.4 Install the Servo Pushrod

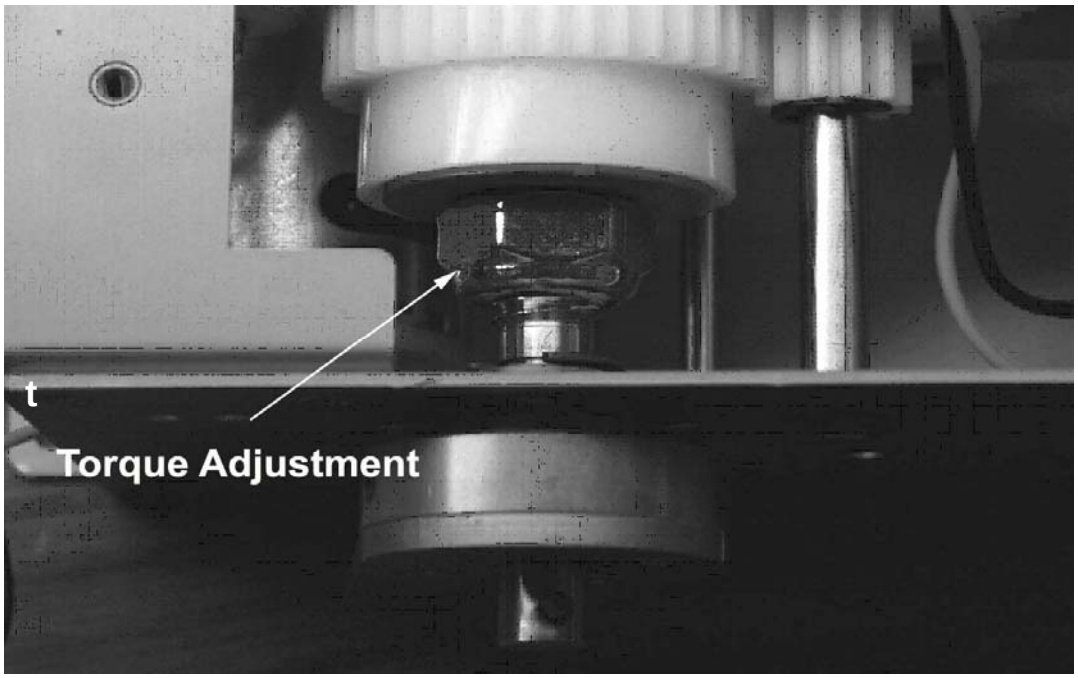
Cut the pushrod to the proper length so that, when the servo is at **neutral**, or centered in its full rotation stop to stop, the elevator is also neutral (see note).

Choose the longest possible crank arm radius that accommodates a pushrod range of movement equal to or exceeding that required for full elevator travel. **Be sure that the rod end bearings never jam due to misalignment as the pushrod angle is varied by different combinations of control system input**. Put the control stick (or control wheel) in all four corners to test this.

Note: The **neutral position** for your elevator will be dependent upon how precisely your flying surfaces are aligned. In many homebuilt airplanes, the elevator must be trimmed for proper (hands off) level flight. It is important to test fly your airplane prior to installing the servo to accurately judge the position of your elevator in trimmed level flight. Remember this position – it is the neutral position for your elevator. An elevator perfectly in trail on the ground does not necessarily equate to its position in level flight at cruise speed.

When attaching the servo pushrod to an elevator bell crank, it is important to keep the two lever arms equal. Measure the distance from the servo crank arm pivot point to the outermost hole in the crank arm. Then drill an attach point in the elevator bell crank that is the same distance from its pivot point. This will assure proper servo operation.

6.5 Setting Servo Override Force (Slip Clutch)



The servo Torque Control nut (the adjustment nut inside the servo on the output shaft) sets the override force - the force you will feel at the stick when the servo clutch begins to slip.

Engage the servo by pressing the **LCD** switch. You should hear the solenoid operate inside the servo housing and the servo crank arm should become firmly held in place by the gear train. Then push the control stick hard enough to override the servo. Using an 11/16 " or 17mm open end wrench set the override force to a value that seems strong enough to give a fairly good pitch authority, but not so strong as to be difficult to override with the control stick. Work toward setting the servo slip clutch to the minimum torque necessary to give enough elevator authority to handle a reasonable amount of turbulence or trim error.

6.6 Adjustment of Servo Rotation Direction and Servo Neutral

After installation wiring is complete the system servo direction and initial zeroing check procedures must be accomplished.

IMPORTANT – Prior to performing step 6.6.1 the system must be powered up and placed in the READY mode for a full 5 minute period to allow the gyro and accelerometers to bias to their zero position. During this time the aircraft must remain perfectly still. Failure to do this may result in an immediate **SERVO CAL TERM** message when performing step 6.6.1 below. After the 5 minute period has elapsed secure power to the EZ 1 system and perform step 6.6.1

6.6.1 Servo Direction Setting - The servo direction must be set so the EZ-1 system knows which way to drive the control system for an increase or decrease in altitude. This is a one time ground setting and **should never be attempted in flight**. To preclude an in flight actuation of this function the rate sensor output is monitored and if any change above a very shallow threshold is sensed the calibration mode is automatically terminated , the **LCD** switch is illuminated RED and the message **SERVO CAL TERM** is displayed on the **LCD** switch. If the **SERVO CAL TERM** message appears on the screen, power must be recycled to repeat the procedure.

Do the following to enter the servo direction setting mode:

Turn on power to the system.

While the **SYSTEM TEST** message is being displayed, simultaneously press and release **both** the **LCD** switch and the **ENCODER** switch. The LCD switch will now display the **SERVO DIR NORM** or **SERVO DIR REV** message.

> **NOTE:** At this point the servo will engage and drive the elevators to the mechanical servo zero position. This position should be close to the elevator neutral position if the servo was installed correctly. If the elevators are not close to the neutral position this is a good time to re-adjust the servo mechanical position.

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a. Rotate the **ENCODER** knob **clockwise** while observing the elevator travel direction. The elevators should move in a direction that would cause an **increase in altitude**. If the direction is correct proceed to step **6.6.2**

b. If the elevators drive in the opposite direction momentarily press the **ENCODER** switch. The LCD message will now read **SERVO DIR REV**. Repeat step **6.6.1.a** above and verify correct elevator directional control is achieved

NOTE: Pressing the **ENCODE** switch while in this mode places the crank arm back in the center (neutral) position.

6.6.2 Servo Position zeroing.

This is a one time ground setup that allows the EZ-1 system to check the straight and level position of the elevators. This is used for internal servo calculations to ensure the clockwise and counterclockwise alarms created in the servo are reasonably accurate and to ensure the servo has reasonable range in both the elevator up and elevator down positions.

During this procedure EZ-1 system measures the servo offset from its mechanical zero. In the event the installation zero (elevator neutral position) violates the allowable limits of the servo mechanical zero position the **LCD** switch will flash RED while displaying the **SERVO ZERO ERROR** message. The remedy for this situation is to reposition the servo crank arm to control system connection until an in-limits condition exists.

The specific procedure is as follows:

a. Perform steps **6.6.1.a and 6.6.1.b**

b. Press the **LCD** switch to sequence from the servo direction mode to the servo zero mode. Observe that the **LCD** switch illuminates green and displays **SERVO ZERO OK.**

c. Use the **ENCODER** knob to position the elevators at the straight and level zero elevator position noted during normal and level flight (this might not be in actual trail but perhaps up or down some fraction of an inch dependent upon the flight characteristics of the aircraft).

d. The **LCD** switch should be illuminated GREEN indicating the mechanical zeroing error is within acceptable tolerances and the zeroing procedure is complete. Turn off system power.

If the switch is illuminated RED the error is in excess of the allowable limit. The servo crank arm connection to the elevator control system linkage must be repositioned to bring this misalignment within specifications. Reposition the crank arm to elevator attach point by lengthening or shortening that arm so that the crank arm assumes a more central location when in the neutral position and repeat steps **6.6.1.a** through **6.6.1.d** until satisfactory results are obtained.

NOTE: Pressing the **ENCODE** switch while in this mode places the crank arm back in the center (mechanical zero) position.

7.0 SYSTEM GAIN and SERVO DEADBAND Adjustment

The System Gain and Servo Deadband Settings optimize the EZ-1 tracking performance for your individual airplane

7.1 SYSTEM GAIN

The system gain adjustment allows the EZ-1 system to be tailored to your individual airplane. The factory setting is a nominal value which should give good performance in most airplanes. However, to achieve best performance in your airplane the **SYSTEM GAIN** adjustment should be optimized.

To optimize the gain setting in your airplane, perform the following steps:

a. Enter the **ALTITUDE HOLD** mode in smooth air at your normal cruise speed after verifying the pitch trim is properly adjusted for level flight.

b. Press the **ENCODER** knob for more than 2 seconds until the **SYSTEM GAIN** setting is displayed.

c. Slowly rotate the ENCODER knob clockwise until jitter or bumping is experienced in the control stick.

d. Rotate the knob counterclockwise until the jitter or bumping just stops. This is the optimum gain setting for your installation.

NOTE: This gain setting is for smooth air tracking. If you enter turbulent conditions and the altitude excursions are more than what you will accept, you may increase the gain (clockwise rotation) to limit the altitude excursion. *A setting of between 40 and 60 has been shown to be optimum* for most aircraft tested during flight evaluation. Your settings should be similar.

7.2 SERVO DEADBAND

The **SERVO DEADBAND** adjustment optimizes servo performance for your particular installation. The “deadband” is an area in the servo rotation where drive signals are momentarily nulled to prevent unnecessary hunting and / or oscillation of the servo mechanism. The lowest setting that gives satisfactory performance is the optimum setting. The factory setting is a nominal value which should give good performance in most airplanes. However, to achieve best performance in your airplane the **SERVO DEADBAND** adjustment should be optimized.

To optimize the servo deadband setting in your airplane perform the following steps:

a. Enter the **ALTITUDE HOLD** mode in smooth air at your normal cruise speed after verifying the pitch trim is properly adjusted for level flight.

b. Press the **ENCODER** knob for more that 2 seconds until the **SYSTEM GAIN** setting is displayed.

c. Press the **ENCODER** knob several more times until the **SERVO DBAND** message is displayed

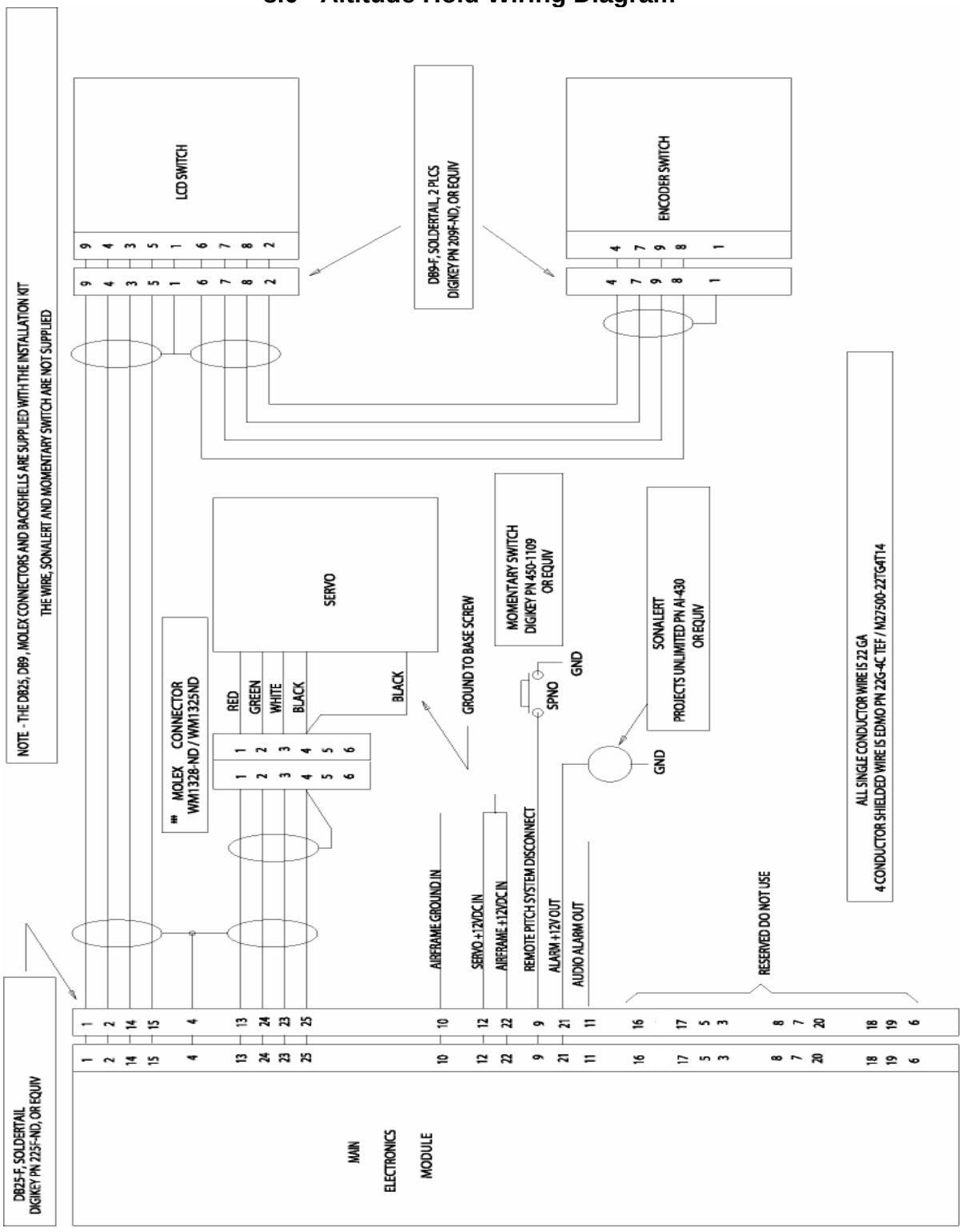
d. Slowly rotate the **ENCODER** knob counterclockwise until jitter or bumping is

experienced in the control stick.

e. Rotate the encoder clockwise until the jitter or bumping just stops. This is the optimum gain setting for your installation.

NOTE – A **SERVO DEADBAND** setting of between 4 and 6 has proven to be optimum in several aircraft used for flight evaluation. Your settings should be similar

8.0 Altitude Hold Wiring Diagram



Altitude Hold Wiring Diagram

Note: the +12VDC input (pins 12 and 22) should be sourced through a circuit breaker with a rating of 3 to 5 amps.

9.0 Glossary of Terms

Brightness	A measure of the intensity of illumination on the LCD switch
Contrast	A measure of legibility of the LCD screen
EEPROM	Electrically Erasable Programmable Read Only Memory
Firmware	Computer program permanently stored in the autopilot memory
G-Force	A measure of acceleration (one G = normal earth gravity)
Gain	Increasing gain results in increased system sensitivity
LED	Light Emitting Diode
LCD	Liquid Crystal Display
PCS	Pilot Command Steering
Processor Interrupt	A signal that will command immediate processor attention
Rotary Encoder	A rotating control knob for adjusting system parameters
Servo	Deflects elevators as required by altitude hold system
Servo Clutch	Allows a moderate force to overcome servo control
Servo Deadband	Adjustable parameter to prevent servo oscillation or “hunting”
SMP	Servo Main Processor
Solenoid	An electro-magnetic actuator that engages the servo gears
RS232	Specification for data transfer protocol between systems

10.0 Contact Information

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