B.T.A AS-07 Automatic Pilot
for Flight Stabilization of Fixed Wing Model Aircraft

B.T.A AUTOMATIC PILOTING SYSTEMS LTD.
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1. PANEL DESCRIPTION - QUICK REFERENCE

1. Radio system Input/Output connector

2. Roll Gain Adjustment Potentiometer

3. TEST. when pushed, simulates autopilot feedback to a climb and right turn of the aircraft. If led on, you should see the right aileron going down and elevator going down (as written on the panel). This is a correct negative feedback reaction.

4. Determine feedback polarity of the autopilot. Should be in the polarity causing the appropriate test reaction as written on the panel.

5. GPS Aircraft Retreiver interface connector

6. Pitch Gain Adjustment Potentiometer

7. LED Indicator shows Automatic (LED ON) or Normal mode (LED OFF), selected from the radio (through the mode input connector)
2. INTRODUCTION

2.1 APPLICATIONS

The B.T.A. Automatic Pilot presents a new approach in flying and controlling radio controlled airplanes. It was designed to enable beginners and unconfident flyers to fly safely. It will also help the more experienced scale flyers by giving them absolute safety and immunity to radio interference, and enable pleasant smooth flight. In the field of special flying for target purposes, filming, advertisement and night flying, B.T.A. offers the tool that turns a normal model into a real drone. The BTA Automatic Pilot combines the top in electronics, and know how in model flying, to give the best available performance from each model.

2.2 CONNECTIONS AND OPERATION

The automatic pilot is connected in the model to the aileron and elevator channels and stabilizes pitch and roll angles (or vertical speed and rate of turn). The angles of the airplane relative to the horizon are dictated by stick position whenever engaged (automatic pilot mode) in air. Centering the sticks will always return the plane to straight and level flight.

2.3 SO WHAT?

This represents a new mode of flying and is known as position flying. It gives performance and possibilities that are impossible with any other radio controlled system. Not to be confused with regular rate gyros, this autopilot really “feels” the airplane’s position. Rate gyros only detect dynamic changes and are therefore unsuitable for position stabilization. The B.T.A. autopilot will save the model from almost any bad position such as spin and dive. A rate gyro could never do that because it can’t sense a dive or return to level flight. (For applications see chapter 13).
2.4 GETTING STARTED

The autopilot is intended for everyone. Flyers can use it to gain confidence and experience. In order to operate the unit safely and correctly the manual must be read and fully understood. Initial calibration could be done by a more skilled flyer until proper operation is achieved.

![Images showing autopilot controls and flight maneuvers.](image)

The AS-07 maintains level flight without any control input.

Turning is accomplished by constantly holding the stick in the required angle.

Climbing or descending is accomplished by constantly pressing the stick up or down.
3. **PRINCIPLE OF OPERATION**  
(U.S. PAT 4964598)

The B.T.A. autopilot stabilizes the airplane in roll (ailerons) and pitch (elevator). Stabilizing a moving airplane is done by sensing the airplane’s position (or attitude) relative to the horizon.

Sensing of roll and pitch directly is difficult and expensive; the B.T.A. autopilot measures airplane’s dynamic movements, which correspond to real roll and pitch. In the roll axis (ailerons), the autopilot measures the change of heading of the airplane to indicate roll. In the pitch axis (elevator), the autopilot measures the change of altitude (height) by means of a sensitive barometric sensor. This signal represents pitch. Since sensing is dynamic, the autopilot will work only in flight. Simulation on the ground is not possible.
3.1 SPECIFICATIONS AS-07

Weight: ............................... 85 grams (3.0 oz.)

Size: ................................. 105x48x21mm (4.1"x1.9"x.8")

Power: ............................... 4.8-6.0V, 20mA (no additional battery required)

Input/output: ....................... Pulse width modulation, 1.5 msec neutral position

Compatibility: ..................... All radio systems (with 1.5 msec neutral)

Type of Stabilization: .......... 2 axis (roll, pitch)

Response time: ................. Roll: 0.5 sec.
........................................ Pitch: 0.3 sec. (depending on gain settings)

Sensors: ............................. 1. Roll rate of turn
........................................ 2. Pitch rate of climb (barometric)

Connectors: ....................... 20 Pin with Radio System Adapter
........................................ 10 Pin GPS Plane Retriever Interface
4. CAUTIONS

- Never take off without knowing which mode it is set to (automatic or normal). Always take off with the autopilot disengaged.
- Don’t fly an autopilot in an airplane that has never flown before. Test flight must be done prior to automatic flight.
- Don’t try to simulate flight on the ground. The autopilot only works in flight.
- Don’t change the wires in the main connector, incorrect polarity will damage.
- Prevent dirt and oil coming into the autopilot through the front panel holes.
- Don’t leave the autopilot in direct sunlight for long time, as this will cause miscalibration due to temperature rise.
- It is highly recommended not to open the autopilot’s box. In any case, do not move the internal potentiometers because they are precisely factory calibrated.
5. INSTALLATION

Install the autopilot wrapped with vibration isolating foam like a receiver. Leave the front panel accessible. The only requirement is that the autopilot should be level in the airplane and the arrows on the panel pointing toward the sky.

The usual place for the autopilot in high wing airplanes is under the wing or somewhere in the fuselage (arrows pointing up during flight). It is sometimes necessary to move the servo tray towards the tail, in order to clear space for the autopilot. In some models, the autopilot can be placed parallel to the wing if it is more convenient. The images on this page show the mounting orientations.
5.1 SEALING

The autopilot is measuring changes in barometric pressure and is therefore sensitive to wind coming into the fuselage during flight. It is essential to seal all holes and openings on the firewall that face the airflow of the propeller. In scales, the front of the aircraft must be inspected for unwanted holes facing the airstream in flight. Sealing is best done with R.T.V. sealant. Operative check of the sealing is described later in chapter 8.1.
6. ELECTRICAL CONNECTIONS

6.1 CONNECTORS

The AS-07 includes a wiring harness to interface with the receiver and servos. The radio connectors are universal and are compatible with all modern radio systems. If in doubt, verify polarity before making any connections. Incorrect polarity will result in damage to the autopilot and or the radio system.

6.2 CONNECTION TO RECEIVER AND SERVOS

The AS-07 can be used with several types of control configurations including, standard, elevon, and flaperon installations. The following diagrams show how the autopilot integrates into the system.

For elevon installations the mixing of the control surfaces is done between the autopilot and the servos. Transmitter elevon or delta mixing must be disabled.

Standard Installation

Elevon (Flying Wing) Installation
Flaperon systems are also an option. Again transmitter mixing must be disabled. Mixing of flaperon is done on the aircraft with a v-tail mixer. Follow the diagram and mixer instructions to get proper surface throws.

6.3 AUTOPILOT ON/OFF
Turn power on. Verify that mode LED is turning on and off with the auxiliary channel switch. On the transmitter, mark the position of the switch that causes automatic mode. (LED on).

6.4 CHECK
Check that aileron stick moves ailerons and elevator stick moves elevator. In automatic mode the swing of the ailerons and elevators will appear smaller (like dual rate).
7. **TEST**

The test procedure is the most important part of the calibration. Be sure it is done correctly. Incorrect position of the autopilot norm/rev switches will result in dangerous and unstable flight (in automatic mode only, of course). It must be understood that there is no connection or influence of the autopilot’s norm/rev switch on the servo’s norm/rev switches in your radio.

While the system is fully connected (including wing servo) and operative, switch the autopilot on (LED on). Then press the test switch (with a screwdriver). The elevator should go down and the right aileron should also go down, as written on the front panel. If not, the elevator and aileron reversing switches should be adjusted.
8. **PRE-FLIGHT CHECKS**
Do not fly an autopilot on an airplane that has never flown before. Test flight will be done without an autopilot. If the airplane has proven itself in flight and the autopilot was installed, tested, and calibrated, proceed.

- Check that all servos are operating to the right directions.
- Start engine.
- Switch autopilot on (aileron and elevator swings are smaller).

8.1 **SEALING TEST**
Switch the autopilot on (engine running). Restrain the airplane. Open and close the throttle in five second intervals. Watch that elevator is not influenced. If considerable deflections are noted, check and improve the sealing described previously in chapter 5.1.

9. **TAKE OFF**
- Turn autopilot off (LED off, aileron and elevator swings are larger).
- Take off in the usual manner.
- Climb to altitude of about 200 feet.
- Trim the airplane.

10. **AUTOPILOT ON**
- Switch the autopilot on. If anything strange happens, quickly switch the autopilot off.
- When switched on, the plane will continue to fly straight and level.
- If everything works well, begin giving left, right, up and down commands. Remember you have to hold the stick constantly. Notice the model rights itself as soon as the stick is centered.
11. **OSCILLATIONS**
   If the model oscillates in flight the gain of the corresponding axis must be reduced. Decrease gain by turning the trimmers counter-clockwise as illustrated. Reduced gain results in less control surface travel when the autopilot is switched on. The ideal gain is slightly lower than the critical gain causing oscillations.

12. **LANDING**
   Do not attempt landing in automatic mode until you understand how the unit works and have properly set up the model. The model must be properly calibrated, flying stable and smoothly in automatic mode, without swinging from left to right. When such calibration has been achieved, automatic mode landings may be attempted. Remember that when flying in the automatic mode the ailerons and elevator have smaller throw, so landing should be planned carefully with moderate approach angles, usually requiring a larger approach radius. When done correctly, landing in the automatic mode is smooth and easy. Approach the runway as usual but faster with moderate descent rate. The faster approach has to compensate for the limited full up elevator command in automatic mode, and to prevent stalling before touchdown.
13. APPLICATIONS APPENDIX AND BACKGROUND

13.1 APPLICATIONS

- As an initial training aid: the model may be flown with the autopilot engaged throughout the flight, after takeoff.
- Advanced training: the model is flown with the autopilot disengaged, but can be engaged if the student experiences difficulties.
- Scale flying: the autopilot is engaged to give better scale flight characteristics by reducing sudden responses, which spoil the look of scale flight.
- Special applications: the autopilot will control the model at the extremes of height and range in events such as cross-country gliding, where visual control can become difficult.
- Enhanced failsafe protection: the autopilot will bring the model to a controlled touch down.

13.2 WHAT IT DOES

This is a true autopilot, and its function should not be confused with that of a gyro or failsafe.

13.3 THE GYRO

As used in model aircraft, this is essentially a damping device for correcting unwanted changes in attitude or heading caused by external forces acting on the model. A gyro will oppose a turbulence-induced roll when fitted on the ailerons of a glider, but it will not bring it back to level flight. If the glider is banked using ailerons, and the control stick is centered, a gyro will not roll the wings level, but will try to keep the model in a bank.

13.4 THE FAILSAFE

The purpose of a failsafe is to prevent the model from continuing to fly away following radio failure, not to land the model safely. What the failsafe does, is to move the servos to pre-programmed positions when the transmitter signal is lost. What the model does next depends on the attitude of the model when the failsafe activated and the flying characteristics of the model, as well as the failsafe control positions.
13.5 THE B.T.A. AUTOPILOT

The main function of the autopilot is to return the model to a pre-programmed flight attitude (normally straight-and-level flight) when the control sticks are centered. It does this regardless of the attitude of the model at that time. The autopilot will even recover the model from an inverted dive or spin.

The autopilot operates via the aileron and elevator channels to control the model (throttle and rudder are unaffected) and is simply plugged in between the receiver and the servos. A spare channel (the gear channel is ideal) is used for engaging and disengaging the autopilot from the transmitter.

The autopilot is powered by the receiver battery and is switched on by the receiver switch — there is no separate power switch. It is engaged and disengaged from the transmitter at any time.

**Autopilot Disengaged**

The model is flown normally and full control response is available. The autopilot is transparent. If the autopilot is now required, perhaps because the pilot has become disorientated, or has lost control of the model, the control sticks are released and the autopilot switched on. The autopilot will now return the model to straight and level flight. This will give the pilot time to regain orientation and control of the model.

**Autopilot Engaged**

The model is still controlled by the pilot. The autopilot will level the model whenever the sticks are centered. Depending on gain settings it will limit the amount of response similar to a dual rate. The sticks now however dictate the roll and pitch angles. When the stick is held it will cause the model to bank. The model will not roll inverted when the autopilot is engaged. The autopilot restricts the attitude of the model and the control inputs, within adjustable limits.
Attitude
The maximum bank and pitch angles may be limited by reducing gains. Reducing gains will increase the time for recovery from unusual attitudes after engaging automatic mode. While flying with the autopilot engaged, it will prevent the model from becoming inverted and will also reduce the risk of inadvertent stalling.

Control Input
The control movements are reduced depending on gain, thus making the model less responsive and easier for the student to control.

Height Control
The autopilot does not have a height lock. It will not hold the model at any particular height. It will return the model towards the height at which the maneuver commenced. If the model is diving steeply and the autopilot is engaged and the sticks are released, the autopilot will recover some of the height lost. The amount of height recovered depends on the steepness of the dive, the steeper the dive, the more height recovered. The autopilot will not stall the model if the throttle is closed. With the controls centered the autopilot will allow a gradual descent. Similarly, if the throttle is fully opened the autopilot will allow a gradual climb. This allows the model to be used in gliders without a power source.
13.6 USE OF THE AUTOPILOT WITH FAILSAFE

The autopilot will operate in conjunction with a failsafe to provide much better protection from loss of transmitter signal. When both are correctly set, the combination will ensure that the model is actually controlled back onto the ground, instead of merely being prevented from continuing to fly away. The failsafe should be programmed to switch the autopilot on. Modern transmitters allow all the channels to be programmed, as well as setting the controls to the required position.

When used for this type of application the failsafe may be set to engage the autopilot, give a small aileron deflection, small up elevator deflection, straight rudder, and engine off. When set in this manner if the radio signal is lost, the failsafe will close the throttle and engage the autopilot, which will then control the model in a shallow descending turn. This will minimize the damage to the model on landing and the turn will reduce the distance the model will travel, particularly if the model was pointing away from the pilot when the failsafe operated.

14 AS-07 with GPS Plane Retreiver

The AS-07 with the optional GPS homing function provides the ultimate protection from flyaways and loss of visual contact. The system includes a small antenna for GPS signal reception and navigation software which will guide the model back to the take off site when activated. The unit has three modes of operation, transparent(off), stabilization, and homing navigation.

14.1 Pigeon Specifications

Weight: ............................ 85 grams (3.0 oz.)
Size: ................................. 105x48x21mm (4.1"x1.9"x.8")
Power: .................. 4.8-6.0V, 50mA (no additional connections required)
Connectors: .................. 10 Pin AS-07 Interface
................................. MCX for GPS antenna
................................. Connector for NMEA output
14.2 GPS Antenna Installation
The antenna must be installed externally for best reception. Use double-sided foam tape to install the antenna with the plastic dome facing the sky.

14.3 Plane Retriever Installation
Mount the GPS module in vibration isolating foam. Install it so the LEDs and gain potentiometer are visible. Connect the antenna and interface cable to the autopilot.

14.4 AS-07 with GPS Plane Retriever Setup
Follow the previous instructions for setup of the AS-07. The main difference is that the input mode switch should be a three position switch. This allows easy selection of the three operating modes. It could also be assigned to a slider or potentiometer. One extreme will be off, center will be stabilization on, and the other extreme will be navigation on. Mark the transmitter accordingly.

Take the system outside and turn the receiver on. After the AS-07 initializes the Plane Retriever will be acquiring the home location. The Power LED should be lit and the Data LED flashes indicating it is receiving data. Initial cold start home point recognition may take up to five minutes while the GPS searches for available satellites.
After initial power up locating home should take approximately 10 seconds after AS-07 initializes. When home is located the GPS OK LED will flash. The model is ready to take off. Switch the mode switch to navigation and verify the Nav On LED lights. The model must be moving for navigation to function, there will be no control deflection while stationary. The pilot can make control inputs with navigation active.

Calibrate the autopilot without switching on the navigation. Do not attempt to adjust the navigation until the stabilization is adjusted and flies the model smoothly. The Plane Retriever is designed to turn at a rate of 10 degrees per second. Adjusting the gain changes the turn rate. If the gain is too high the retriever will overshoot the heading to home and will have to correct several times. This appears as the model doing S turns finding the way home. The ideal gain results in a 10 degree per second turn of the model. This will appear as the model turning directly home, with little or no correction thereafter. Changing autopilot gain settings will require adjustment of the Plane Retriever gain. NEVER take off with the Navigation on!! As before take off with the mode switch in the off position. After climbing to a safe altitude engage the navigation. The model will start turning toward the take off site. Once heading toward the site it will level and continue flying. If it overcontrols the nav gain must be reduced. If it levels and corrects again, gain must be increased. Once home location is reached it will begin to circle or fly a figure eight pattern. The unit can’t determine where the flight line is and may fly well behind it for several reasons. If it is critical this doesn’t happen, power up the aircraft on the runway or flying field rather than in the pit area. The pilot can control the model while navigation is on but it will continue to correct toward home. It is best to avoid inputting aileron or rudder commands, but altitude may be adjusted with throttle and elevator.

Thank you for purchasing the B.T.A. autopilot, the world’s first automatic pilot commercially available for model airplanes. This instrument is elaborate enough to fit the most demanding applications and at the same time is ideal for beginners as a training aid. Like all radio controlled equipment the AS-07 autopilot must be appropriately maintained and operated. Responsibility of proper usage lies on the user and it is therefore essential to read and follow this manual step by step. Good luck and joyful flights.
OTHER B.T.A. PRODUCTS

1. Magnetometer (electronic compass), enables to fly in a required azimuth beyond eye contact (or radio range).

2. Altitude hold modified AS-06 Autopilot.

3. Special mixer circuitry for unconventional platforms.

4. Video transmitters and cameras.

5. Stabilized video cameras for flying platforms.


7. GPS navigation systems for RPV out of sight navigation.

8. L-BAND F.M conversion to FUTABA etc... for increased flying range.

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