



Operating Handbook

For

Digiflight II SERIES AUTOPILOTS



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General Introduction

The TruTrak autopilot can be defined as being an orthogonal rate system. This means that gyroscopic rate sensors are installed so as to sense motion about each of the major axes (roll, yaw, and pitch). These sensors generate the fast signal responses necessary to create an autopilot with the best possible dynamic performance.

To fly an aircraft well about the axis controlled by the ailerons, velocity of aileron movement must be directly proportional to the rate of roll for small movement. This means that aileron position corrections do not lag behind motion of the craft about the roll axis. Aileron control systems that use a turn coordinator, which senses twice as much azimuth as roll rate, cannot do this. Instead, in turbulence, yaw disturbances cause undesired aileron movement. In some aircraft this effect is so severe that the controls may even move momentarily in the wrong direction.

The challenge at TruTrak is to create, beyond question, systems with the very best dynamic performance available—systems that need not be disengaged in turbulence, but instead provide function when most needed.

The complete TruTrak flight control system combines within a single panel-mounted programmer/computer package which includes all the electronic and sensing elements needed for the roll and pitch functions and interfaces to a rate-gyro-controlled yaw damper.

Basic directional control is provided by digital selection of a GPS track to be flown. This replaces heading selection on the DG, and eliminates drift as well as crosswind correction. In the GPS steering mode of operation, the system responds to digital guidance information so as to fly a complex navigation program.

The vertical portion of the system contains a pressure signal source for altitude and vertical speed information, an airspeed signal source, and a high performance pitch rate gyro. These signals are combined to provide performance equal to that of the most expensive autopilots. Also by having airspeed information the system is stall proof. It is expected that other systems will soon be coming out with this same feature.

For any set of features all TruTrak computers are identical. Servos likewise are identical in velocity response. Servos do differ according to total torque required. By providing setup functions in the programmer for system activity and torque, one TruTrak programmer-servo combination can fly any aircraft.

As a starting point in understanding how to operate the TruTrak system, the following describes the presentation of data, the operating controls, and the procedures for selecting modes of operation.

POWER UP—AIRCRAFT STATIONARY

SEE INITIALIZING THE AUTOPILOT PAGE 4

Mode and Data Display

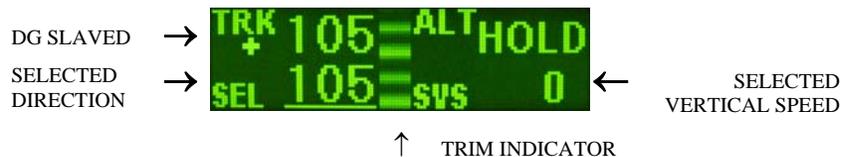
This display normally shows operating modes and associated numerical data. It is also used to display setup mode screens and the setting of associated numerical data. When displaying operating modes, the left side shows lateral data and the right side shows vertical data. (See figure below.) The upper left display labeled **TRK** shows the electronic DG slaved to GPS track. When the GPS track is not available **TRK** will be replaced by **HDG**, which means the autopilot now uses an internal source of magnetic information for direction. The lower left display labeled **SEL** shows the selected direction of flight. In the Digiflight II and IIVS, the upper right shows whether or not the unit is in the altitude hold mode. The lower right display shows selected vertical speed or whether the autopilot is on or off.

With the Digiflight IIVS, the vertical space between the left and right hand display

area is used to show pitch trim. This display consists of three horizontal bars spaced vertically as the rungs on a ladder, and are made to move up or down when the aircraft is in need of being trimmed.

In the upper left where direction is shown, a flashing indicator is present beneath **TRK** or **HDG**. When there is GPS serial data present but no position fix, this will be a flashing period. Once GPS position data becomes valid this will be a flashing asterisk. If GPS flight plan information is being received over the serial channel or if the programmer is a Digiflight IIVSG and GPS steering information is being received, a flashing plus sign will indicate the presence of a useable steering (**GPSS** mode) or waypoint to waypoint (**GPS NAV** mode) signal.

A cursor in the form of an underline is shown beneath the **SEL** numerals. This is used to indicate that an underlined number will be set by rotation of the encoder knob.



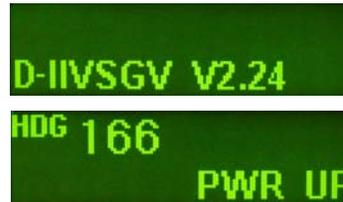
Controls

The Digiflight II series autopilot uses the simplest controls available. All programming is done via a rotary encoder knob and two buttons labeled MODE and ALT. The MODE button toggles between the default (TRK) mode and the GPSS mode (or GPS NAV mode if GPS steering is not available), as well as moves the cursor back to the SEL numerals. The ALT button engages altitude hold or moves the cursor to the SVS numerals. If in the GPSS mode, the ALT button will engage the GPSV mode, if it is available. Both buttons are also used to enter the setup modes as well as maneuver through the setup screens. Engaging the autopilot can be done by either momentarily pushing and releasing the encoder knob on the programmer or by pushing and holding the switch located on the control wheel or stick for more than two seconds and then releasing. Disengaging can be done either of two ways: by pushing and holding the encoder knob on the programmer for approximately three seconds and then releasing the knob, OR by momentarily pushing and releasing the switch located on the control wheel or stick. This means that in addition to disengaging the autopilot, this switch also provides the function referred to

as Control Wheel Steering in that the autopilot synchronizes to both direction and vertical speed upon being engaged.

Initializing the Autopilot

The autopilot master switch should be in the off position when the engine is started. Aircraft electrical systems can generate voltage transients during an engine start, and like other avionics systems, the autopilot should not be subjected unnecessarily to these conditions. After start up, turn on the autopilot master switch and hold the aircraft stationary as the internal gyros are initialized. The software version will be momentarily displayed in the lower left. This takes approximately ten seconds during which time the display will show the words PWR UP in the lower right.



When initializing is complete PWR UP will change to AP OFF



GPS Acquisition

Beneath the word HDG a flashing period • will appear each time the GPS sends a message to the autopilot (once per second). This indicates the GPS is working but has not yet obtained a position fix. As long as the period is shown, the heading display cannot transition to the TRK mode.

When the GPS does obtain a fix, the period will be replaced by an asterisk *. This means that when a certain velocity is attained HDG will be replaced by TRK. This happens at approximately 10 Knots ground speed as detected by GPS and will even occur at rapid taxi speeds.

Digiflight II

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral track mode, and it will be synchronized to the direction being flown at the time. The number following SEL (Selected direction) is underlined, meaning that rotation of the encoder will select heading. Rotation of the knob when it is not depressed will cause 5° steps of SEL and when it is depressed the steps will be 1°.



TRK 104
SEL 104 AP ON

If a GPS flight plan has been entered into the GPS, pushing the MODE will engage the GPS NAV mode and a flashing plus sign will show. In the GPS NAV mode, the autopilot will follow a flight plan programmed into the GPS.

The autopilot must, however, over-fly each way point prior to turning and intercepting the next course line.



TRK 103
GPS NAV AP ON

If the GPSS option has been added, pushing the MODE button will engage the GPS steering. In the GPSS mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS).



TRK 093
GPSS AP ON

Magnetic Back-Up Mode

The lateral modes previously described are based on GPS track being present. When GPS is lost, the DG

display is slaved to a magnetic heading source contained within the programmer and TRK is replaced with HDG. This magnetic mode is only a backup and would seldom be needed; however, it does provide a means of selecting and maintaining a drift-free direction of flight. If the GPSS signal source is functional, the GPSS mode will remain functional.

Altitude Hold Mode

When the autopilot is engaged it will be in the basic lateral track mode, and will synchronize to the direction being flown at the time. The pitch servo will not be engaged at this time. To engage the altitude hold the aircraft must be at the desired altitude and be trimmed for level flight. After trimming the aircraft, to enter the altitude hold mode, simply press and release the ALT button. The display will show:



TRK + 104 ALT HOLD
SEL 104 AP ON

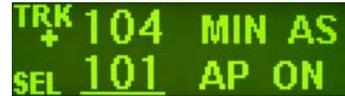
If an altitude change is desired, it is necessary to turn off the altitude hold. To do this, press and release the ALT button. The display will show:



TRK + 104
SEL 104 AP ON

Minimum and Maximum Airspeed

The Digiflight II series autopilots have a minimum and maximum airspeed feature. These are added only for safety. If the autopilot is in altitude hold and the pilot reduces power to a point at which the airspeed falls below the minimum airspeed set in the autopilot, the autopilot will allow the aircraft to begin a descent and flash **MIN AS** on the display.



TRK + 104 MIN AS
SEL 101 AP ON

Likewise if the autopilot is in altitude hold and the pilot adds power to a point at which the airspeed reaches the maximum airspeed, the autopilot will allow the aircraft to climb and will flash **MAX AS** on the display.



TRK + 104 MAX AS
SEL 101 AP ON

Gyro Set

When the initializing has been done correctly, the gyros should already be centered at the time of take off. If confirmation of this is desired, with the aircraft stationary on the runway and the autopilot disengaged, pressing and holding the encoder knob will

put the gyros in the fast centering mode. The knob should be depressed for approximately 3 seconds during which time the words **GYRO SET** will be displayed. Continue depressing the knob for 10 seconds to set the gyro center.



Power Loss

If there is a momentary loss of electrical power, the

autopilot will disengage. The autopilot gyros must now be manually re-initialized using the **GYRO SET** operation. Manually fly the aircraft in a straight line as steadily as possible, while holding in the knob for at least ten seconds after the words **GYRO SET** appear in the display. After approximately ten seconds have elapsed, release the knob. The autopilot may now be re-engaged, and any residual gyro offset will be slaved away automatically.

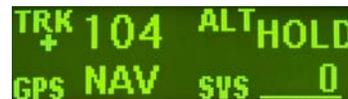
Digiflight IIVS

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral mode, and it will synchronize to both the direction and vertical speed being flown at the time. The number following **SEL** (Selected direction) is underlined, meaning that rotation of the encoder will select heading. Rotation of the knob when it is not depressed will cause 5° steps of **SEL** and when it is depressed the steps will be 1°.



If a GPS flight plan has been entered into the GPS, pushing the **MODE** button will engage the **GPS NAV** mode and a flashing plus sign will show. In the **GPS NAV** mode the autopilot will follow a flight plan programmed into the GPS. The autopilot must, however, over-fly each way point prior to turning and intercepting the next course line.



If the **GPSS** option has been added, pushing the **MODE** button will engage the **GPS Steering**. In the **GPSS** mode the autopilot follows lateral

steering or bank commands generated by a navigation system (EFIS or GPS). Once in the GPSS mode, pushing the ALT button will enter the GPSV mode as well. This feature will only be available when coupled to certain EFIS systems or a GPS with vertical GPS steering outputs.



TRK +104 ALT HOLD
GPSS SVS 0

Magnetic Back-Up Mode

The lateral modes previously described are based on GPS track being present. When GPS is lost, the DG display is slaved to a magnetic heading source contained within the programmer, and TRK is replaced with HDG. This magnetic mode is only a backup and would seldom be needed; however, it does provide a means of selecting and maintaining a drift-free direction of flight. If the GPSS signal source is functional, the GPSS mode will remain functional.

Vertical Modes

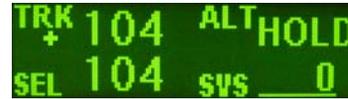
When the autopilot is engaged it will synchronize to the direction and vertical speed being flown at the time, the lower right section of the display shows SVS (selected vertical speed). To enter

altitude hold at any time, push and release the ALT button two times.



TRK +104 ALT HOLD
SEL 104 SVS 0

If an altitude change is desired, momentarily push and release the ALT button and the cursor will move over to the selected vertical speed.



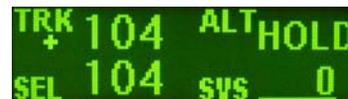
TRK +104 ALT HOLD
SEL 104 SVS 0

Rotation of the encoder knob will now change the selected vertical speed.



TRK +104
SEL 104 SVS 400+

If the cursor is under the SVS number a single click of the ALT button will select zero vertical speed. If the selected vertical speed is set to zero, the display will show:



TRK +104 ALT HOLD
SEL 104 SVS 0

Once the desired vertical speed has been selected, momentarily pushing and releasing the MODE button will move the cursor back to SEL, or after approximately seven seconds without moving the

encoder, the cursor will move back to SEL.

If the autopilot is coupled to a GPS or EFIS system which can provide vertical GPS steering, once in the GPSS mode, pushing the ALT button will enter the GPSV mode as well. To use the GPSV mode with the GNS 480, the aircraft must be below the virtual glide slope and the autopilot must be in altitude hold. When approach is initiated and the CDI becomes active, the GPSV button can then be pushed and the unit will enter the GPSV mode. The first screen will show as below:



TRK 104 ALT HOLD
+ GPSS GPSV FLG

When the VDI is no longer flagged, the unit will enter GPSV hold, and the display will show as below:



TRK 104 ALT HOLD
+ GPSS GPSV HLD

Once the VDI has been above the center by one dot for at least 7 seconds the GPSV mode will ARM, and the display will show:



TRK 104 ALT HOLD
+ GPSS GPSV ARM

As the VDI passes through center, the autopilot will couple

to the virtual glide slope, and the display will show that the autopilot is now coupled to the virtual glide slope as below:



TRK 104
+ GPSS GPSV ↓

Setting Pitch Trim

The pitch servo contains a torque sensor that sends a signal to the computer when the up or down force greater than a threshold value is required to fly a selected flight condition. When this signal indicates an out of trim condition that persists in one direction for more than a pre-set length of time, the three moving horizontal bars will come into view and move according to the direction in which trim is required. The pilot is then required to operate the trim control (electric or manual) so as to bring the system to neutral trim. With mechanical trim this is easily done, but with electric systems it may be necessary to develop a technique. If the trim is slow enough, the pilot has plenty of time to react when the bars disappear before the trim condition is reversed. With a fast trim it will be necessary to tap or pulse the trim button so that it will be slow enough to turn it off before going too far. When a reversal takes place, a slight tap in the opposite direction may be required to get the bars to stay off. Finally

when the bars have been made to disappear and there has been no speed change, the bars can be ignored if they reappear in that it is known the aircraft is close to being in trim.

Minimum and Maximum Airspeed

The Digiflight II series autopilots have a minimum and maximum airspeed feature. These are added only for safety. This feature is easier described using the Digiflight IIVS model as an example. If the pilot commands a vertical speed climb in which the aircraft slows to the minimum airspeed, the aircraft will maintain that airspeed and will flash **MIN AS** on the display.



TRK 104 MIN AS
SEL 104 vs 2000+

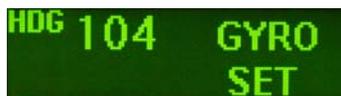
Likewise if the pilot commands a vertical speed descent in which the aircraft accelerates to the maximum airspeed, the autopilot will not fly the selected vertical speed, but will maintain the maximum airspeed and flash **MAX AS**.



TRK 104 MAX AS
SEL 104 vs 1000+

Gyro Set

When the initializing has been done correctly, the gyros should already be centered at the time of take off. If confirmation of this is desired, with the aircraft stationary on the runway and the autopilot disengaged, pressing and holding the encoder knob will put the gyros in the fast centering mode. The knob should be depressed for approximately 10 seconds during which time the words **GYRO SET** will be displayed.



HDG 104 GYRO SET

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage. The autopilot gyros must now be manually re-initialized using the **GYRO SET** operation. Manually fly the aircraft in a straight line as steadily as possible, while holding in the knob for at least ten seconds after the words **GYRO SET** appear in the display. After approximately ten seconds have elapsed, release the knob. The autopilot may now be re-engaged, and any residual gyro offset will be slaved away automatically.

Digiflight Setup Procedure

The setup consists of setting activity, torque, serial baud rate, bank angle setting, micro activity, minimum airspeed, maximum airspeed static lag, and magnetometer calibration. To enter the lateral setup mode, press and hold the MODE button for approximately 3 seconds, until the first setup screen appears. The first setup screen shows the current value for the activity of the aileron servo, with an underline under the present setting of activity. A typical screen might show:



```
LAT ACTIVITY 3
EXIT NEXT
```

The underlined number is set by rotating the encoder knob. Turn this knob to set the activity level to the desired value for the particular aircraft. Any value between 0 and 24 may be chosen. In this example, the value of 2 will be selected. Activity should be set so as to not be excessive in turbulence and yet sufficient to fly without hunting in still air. (Any lost motion or play between the servo and the control surface can cause hunting in still air).

Once activity is set to the desired value, press and release the ALT button to advance to the next setup screen.



```
LAT TORQUE 12
PREV EXIT NEXT
```

In a manner similar to activity, use the encoder knob to select the desired value of roll servo torque. This value should be between 7 and 12. A default value is set at the factory but may need to be modified to suit a particular aircraft. The value chosen should be sufficient to fly the aircraft, but not so much that it is difficult to override the autopilot if necessary.

Having selected the desired torque level, again press and release the ALT button to advance to the next setup screen. The unit will now show the next screen:



```
BAUD 9600
PREV EXIT NEXT
```

The value shown represents the speed of the primary RS-232 interface to the external GPS unit. By default at the factory it is set to 9600 baud. However, it may be set to any of 600, 1200, 2400, 4800, or 9600 baud. Consult the manual for the GPS unit and follow its setup instructions to determine its setting and set the baud rate of the autopilot to the same value. The autopilot will recognize NMEA-0183 protocol

or Garmin protocol (moving map output).

Once the desired baud rate or Garmin protocol has been selected, again press and release the ALT button to advance to the next setup screen. The unit will now show the next screen:

```
BANK ANGLE MED
PREV EXIT NEXT
```

The bank angle setting can be adjusted to suit the pilot. This setting controls how much bank the autopilot will command when in a turn. This will not change the flight dynamics of the system and any of the three settings will fly the aircraft equally well. Once the desired bank angle setting is selected, press and release the ALT button to advance to the next setup screen. The unit will now show the next screen:

```
MICROACTIVITY_0
PREV EXIT NEXT
```

The micro activity setting in most aircraft will be left at zero (0). Micro activity is used only in aircraft in which a slow wing rock has been observed in very still air. Sometimes there will be a small amount of lost motion in an aircrafts control system, and the micro activity setting is a way to compensate for the lost motion. Press and release the ALT button to advance to the next setup

screen. The unit will now show the next screen:

```
GPSS GAIN 16
PREV EXIT NEXT
```

This setup screen is used to increase the bank angle that the autopilot will fly in GPS Steering mode. Increase the value to increase the allowable bank angle. Press and release the ALT button to advance to the next setup screen, which is shown below:

```
YAW DAMPER? N
PREV EXIT NEXT
```

Set the Yaw Damper? to Y if there is a yaw damper installed and N if there is not a yaw damper installed. Press and release the ALT button to advance to the final setup screen.

```
MAG CAL? N
PREV EXIT
```

This setup allows the internal magnetometer in the unit to be compensated for any internal magnetic disturbances within the aircraft, and should be performed once the autopilot is installed in the panel of the aircraft. It may need to be repeated if the autopilot is moved within the panel, or if new equipment is installed nearby. In order to skip this

step, press and quickly release the knob while N is selected.

If calibration is desired, it must be done in the air on a day in which there is little wind or turbulence. The autopilot will turn the aircraft through a full circle, using the GPS signal as a reference to calibrate the internal magnetometers.

The aircraft is turned, first to North, then East, then South, then through West, then back through West, and final will fly West. At each step, the heading is maintained for approximately 10 seconds while the autopilot gathers and averages the data from the magnetometer.

The magnetometer is initially calibrated at the factory for operation in an environment free of magnetic disturbances, and should be functional, though not accurate, when mounted in the aircraft. To calibrate the magnetometer, the aircraft must first be trimmed for level flight.

- (1) Rotate the encoder knob to select Y in the setup screen.
- (2) Press and release the encoder knob to begin the setup sequence. The screen will now show:



CALIBRATING
TURNING NORTH

The aircraft will now turn to North using GPS as a reference. Once this is done, the screen will now show:



CALIBRATING
HOLDING NORTH

After a period of approximately 10 seconds, the screen will show:



CALIBRATING
TURNING EAST

Again, the aircraft will turn to a heading of 090. In the same manner as before, the screen will say **HOLDING** for ten seconds. This process is continued through South and through the multiple crossings of West. Once the westerly data has been averaged for ten seconds, the process is complete and the screen will show:



MAG CAL DONE
PRESS ENTER

At this time, press and release the encoder knob to confirm the calibration and enter the resulting data into permanent memory. Once the magnetic calibration is complete the autopilot will be in the HDG mode, so as to allow the pilot to test the heading mode. To return to the normal track mode, disengage and re-engage the autopilot.

This concludes the lateral setup procedure.

To configure the pitch portion of the autopilot push and hold the ALT button for 3

seconds. The first setup screen allows the pitch axis to be turned on or off. The default of on will always be selected after a power cycle.



To turn the pitch axis off, select off, and click the knob to exit. To advance to the next setup screen, press and release the ALT button, the next setup screen is shown below:



Turn the encoder knob to set the activity level to the desired value for the particular aircraft. Any value between 0 and 24 may be chosen. In this example, the value of 3 will be selected.

Once activity is set to the desired value, press and release the ALT button to advance to the next setup screen:



In a manner similar to activity, use the encoder knob to select the desired value of pitch servo torque. This value should be between 7 and 12. A default value is set at the factory but may need to be modified to suit a particular aircraft. The value

chosen should be sufficient to fly the aircraft, but not so much that it is difficult to override the autopilot if necessary.

Having selected the desired torque level, again press and release the ALT button to advance to the next setup screen. The next screen will show:



Use the encoder knob to select the minimum airspeed at which the autopilot will fly the aircraft. This speed should be a safe margin above a stall. Press the ALT button to advance to the next setup screen. The next screen will show:



The maximum airspeed value is the fastest indicated airspeed the autopilot will fly, independent of what it is commanded to do. Rotate the knob to adjust this airspeed to a value safely below the red line airspeed, but above the normal cruise speed. Select the desired value, and then press the ALT button to advance to the next setup screen.

The next screen in the setup procedure is the static lag setup screen. This setting should only be changed if autopilot tends to

oscillate in pitch during altitude hold, due to lag in the static system. The display will show:



A green monochrome display screen showing the text 'STATIC LAG' followed by a large '0' with a horizontal line underneath it. Below this, the words 'PREV', 'EXIT', and 'NEXT' are spaced out horizontally.

Rotating the encoder knob will change the number as in previous setup screens. Having selected the desired value, press the ALT button to advance to the next setup screen. The next screen will show:



A green monochrome display screen showing the text 'MICROACTIVITY' followed by a large '0' with a horizontal line underneath it. Below this, the words 'PREV', 'EXIT', and 'NEXT' are spaced out horizontally.

As before in the lateral setup mode, the micro activity setting in most aircraft will be left at zero (0). Micro activity is used only in aircraft in which a slow oscillation has been observed while in altitude hold, in very still air. Sometimes there will be a small amount of lost motion in an aircrafts control system, and the micro activity setting is a way to compensate for the lost motion. Press and release the ALT button to advance to the final setup screen.



A green monochrome display screen showing the text 'HALF-STEP?' followed by a large 'N' with a horizontal line underneath it. Below this, the words 'PREV' and 'EXIT' are spaced out horizontally.

This setting in most cases will not need to be changed. If the half step setting is set to Y (yes), then the pitch servo will

now have higher resolution, and take smaller steps. While this setting will make the servo take smaller steps, it will decrease the amount of available torque. This setting should be left at N (No), unless it is observe that the nose moves up and down very slightly while in altitude hold in very still air. Press and release the knob and the display will return to normal flight screen.

Contrast Adjustment

The Digiflight II contrast should only be adjusted while on the ground. To enter the contrast adjust mode, with the autopilot powered off, push and hold the encoder knob in. Turn on the power to the autopilot, and after 1 second release the knob. The display will show the current contrast setting.



A green monochrome display screen showing the text 'CONTRAST' followed by a large '7' with a horizontal line underneath it.

Rotate the knob to select the desired contrast ratio. Too low a number and the words will fade out on the display, and too high a number the background will become dark, and the text unreadable. To exit the contrast adjustment screen, press and release the encoder knob.

This concludes the Digiflight II series autopilots.



TruTrak Flight Systems, Inc.

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