TS

Installation Manual

For

DigiFlight Series Autopilots

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INSTALLATION MANUAL

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DigiFlight Series Autopilots

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Mechanical Considerations

⚠️ The installation information in this section is extremely important and must be <u>clearly understood</u> by the installer. Improper servo installation or failure to observe and diagnose installation problems prior to flight can result in extremely serious consequences, **including loss of ability to control the aircraft**. If there are <u>any</u> questions on the part of the installer it is mandatory to resolve these questions <u>prior</u> to flight of the aircraft.

Most modern experimental aircraft use push-pull tubes to drive the primary controls. These tubes generally have a total travel of 3" or less; therefore, it is best to connect the autopilot servo to the primary control by the same method. This connection consists of an arm on the servo connected by a push-pull rod to the primary control. Rod-end bearings are required on each end of the push-pull rod.

⚠️ The servo arm **must not** rotate even **near** to the point called OVER CENTER, the point at which the primary aircraft control would **lock up**.

This is a condition that would result from the servo being back driven when the pilot operates the controls, or from the servo itself driving the controls to a stop. To protect against this mechanical stops are supplied with the servos. These stops are drilled so that they can be mounted at different angles as required (18° intervals).

⚠️ In addition to the proper use of the stop it is important to know the amount of travel on the primary control that the servo can handle. With the push rod connected to the outermost hole (1 ½") the travel on the primary cannot exceed 2 ½", the intermediate hole 2 1/16", and the inner hole 1 5/8".

⚠️ It is important to note that at the neutral point of the control the SERVO ARM must be PERPENDICULAR to the push rod, and that the stop must be mounted so as to limit travel as near as possible to equal amounts in both directions. In certain factory-designed installations there may be well-proven exceptions.

There will be installations in which space does not permit the use of the stop. When this is done the aircraft's primary control stops must be positive and care must be taken to be sure that at the neutral point the servo arm is perpendicular to the push rod, and that the travel limits of the servo arm are not exceeded.

There are installations in which the travel of the push-pull tube exceeds the allowable 2 ½". For such installations, the drive can be applied to a bell crank at a radius point that moves the desired 2 ½" of maximum allowed travel in the outermost hole of the arm.

When there is no way to have a drive point of less than 2 ½" or when the primary control is cable-driven it is necessary to use the capstan-cable servo drive. When this is done the servo should be mounted so that the 1/16" diameter cable which wraps around the capstan when extended parallel to the primary cable is approximately 3/16" from the primary cable. If the primary control travel does not exceed 5" the cable locking pin will be 180° away from the point at which the cable leaves the capstan. When the primary control is at the neutral point this means the total cable wrap around the capstan is 360°. If the primary control travel is greater than 5" the cable wrap is 720°and the pin is adjacent to the output point when the primary control is at the neutral point.

The cable clamps when properly installed will not slip and thus get loose, but it is desirable to nicopress or swedge a fitting on to the cable so as to provide added assurance that the cable will not become slack. If the bridle cable is not sufficiently tight there will be lost motion in the autopilot drive. This will result in hunting (oscillation).

Pitot and Static Connections (DigiFlight 200 / 200 VS Only)

All multi-servo TruTrak autopilots require connections to the pitot and static lines. The preferred method of this connection would be tee fittings near the aircraft's altimeter. The static line for the autopilot requires due care in its construction, as excessive lag or insufficient static orifices can cause the autopilot to oscillate (hunt) in pitch. Although there is compensation within the autopilot sufficient to handle moderate amounts of lag, the importance of a good static port and line cannot be overstated. In some cases problems can be caused by having a large number of devices (including the autopilot) connected to a single, insufficient, static port. In other cases, the static line itself is adequate but there are one or more devices connected to the same line, one of which has a large static reservoir. A simple remedy for this problem if it occurs is a tee-fitting near the static port, and a dedicated line to the autopilot only. Obviously, an insufficiently-large orifice coupled with large static reservoirs can aggravate the problems associated with lag.

Magnetic Considerations

Because the autopilot contains a built-in magnetometer for a backup source of heading in the event of GPS loss, it is important to try to locate the programmer away from known sources of magnetic disturbance. The calibration procedure can account for a moderate amount of fixed disturbance (for example, nearby iron objects) but it cannot adjust for changing magnetic fields such as might be generated by certain electrical devices. One known source of such problems is the "Flag" mechanism in some older DG or HSI devices. These units use a solenoid to hold the flag out of sight, and the magnetic field will then change when the flags come and go. If at all possible, place the autopilot so as to be as far as possible from such devices. A hand-held compass can be used to assist in finding such problems prior to installation of the autopilot. Even a few inches can make an appreciable difference in the magnetic disturbance level. It should be noted also that strobe light controls generate very strong currents in their wiring, thus they will create a periodically pulsating magnetic field disturbance. Shielding has no effect on this problem; the only solution is to keep strobe light wiring as far away as possible from any electronics which can be affected by pulsating magnetic fields.
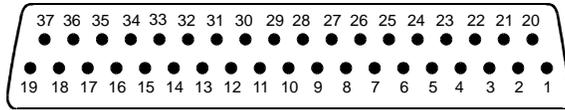
RFI/EMI considerations

The autopilot programmer is shielded and does not generate any appreciable level of electromagnetic interference. Moreover, the servo lines (except for power and ground) are low-current and cannot contribute to RF interference. The servo power and ground lines do have switching currents through them, but so long as there are no parallel runs of servo power and ground lines with such things as poorly-shielded antenna lines or strobe light power lines, there is no need to shield the servo harnesses.

The autopilot itself has been internally protected from RF interference and has been tested under fairly extreme conditions, such as close proximity to transmitting antennas. However, it is always good practice to insure that such antennas are properly shielded and not routed directly over or under sensitive panel-mounted electronic equipment. Most problems in this area are the result of improper RF shielding on transmitting antennas, microphone cables, and the like. The most sensitive input to the autopilot is the Control Wheel Switch input. This line should not be routed in parallel with transmitting antennas or other sources of known RF interference. If necessary, it can be shielded with the shield connection to pin 19 of the autopilot connector.

Electrical Wiring

All TruTrak DigiFlight series (DigiFlight 100, DigiFlight-200, and DigiFlight-200VS) autopilots have consistent wiring requirements. Therefore, this manual covers all such units, with special notations covering any differences between the units. The DigiFlight-200 programmer is mechanically identical to the DigiFlight-200VS and differs only in its internal circuitry and software. The table below provides a brief explanation of each pin function on the main 37-pin connector P101.

```
37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20
 •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •
  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •  •
  19 18 17 16 15 14 13 12 11 10  9  8  7  6  5  4  3  2  1
```

Rear 37-Pin Connector P101
viewed from rear of unit

P101 Pin	Function		Notes
1	Dedicated ground connection for Pitch Reverse Jumper.		
2	**Pitch Reverse Jumper**, present or absent, as follows:	Direction of servo arm / capstan rotation (as viewed from face of the servo body) for **UP** elevator	DigiFlight 200 / 200VS Only. See note 4 on wiring diagram
	Pin 2 open (no connect):	Servo CCW (counter-clockwise) ➔ UP	
	Pin 2 Jumpered to pin 1:	Servo CW (clockwise) ➔ UP	
3	**Auxiliary RS-232 Output**. Presently unused, intended for future expansion.		
4	**LAMP1** (see also pin 18) A source of variable DC from external dimming source. Drives the LCD backlighting circuit. If left disconnected, backlight will be full-on.		Dimmer is wired based on supply voltage. See note 2 on wiring diagram
5, 6, 7 8,9	Reserved. Do not connect to these pins.		
10	**Pitch Servo Torque Control**. A signal from the autopilot to the pitch servo which sets the amount of torque to be delivered by the servo.		DigiFlight 200 / 200VS Only.
11	**Pitch Servo Trim Sensor**. A signal from the pitch servo to the autopilot which indicates an out-of-trim condition and its direction.		DigiFlight 200VS Only.
12	**Autopilot Master** (+12 to +28 V DC). The autopilot itself draws less than 0.5 ampere. Most of the current required by the autopilot system is used by the servos (up to 1A per servo).		
13	Reserved. Do not connect to this pin.		
14	**Pitch Servo control lines**. These lines cause the stepping motor in the pitch servo to run in the appropriate direction at the desired velocity. They are small-signal lines and do not have any substantial current-carrying capability or require any special shielding. Connect to pitch servo as shown on wiring diagram.		DigiFlight 200 / 200VS Only. Do <u>not</u> attempt to reverse servo direction by swapping wires
15			
16			
17			
18	**LAMP2** (see explanation for pin 4, above).		
19	**Ground Connection**. Provide #20 AWG to common grounding point.		
20	**Control Wheel Switch**. Connect as shown in wiring diagram to a SPST momentary switch located remotely to the autopilot for convenient engage/disengage function.		
21 22, 23, 24	Reserved. Do not connect to these pins.		
25	**Primary Serial Input**. Baud rate selectable 1200,2400,4800 or 9600 baud. Automatically decodes NMEA-0183, Garmin Aviation Format, or Apollo/UPSAT Moving-Map or GPSS format. Provides directional reference to the autopilot.		
26	**ARINC-A**	Digital differential signals from Garmin, Sierra, or other panel-mount receiver which provide directional steering commands (GPSS) to autopilot	GPSS Option Only
27	**ARINC-B**		GPSS Option Only
28	**Roll Servo Torque Control**. A signal from the autopilot to the roll (aileron) servo which sets the amount of torque to be delivered by the servo.		GPSS Option Only
29	Reserved. Do not connect to this pin.		
30	**Auxiliary RS-232 Input**. Presently unused, intended for future expansion.		
31	No Connection. Reserved for future expansion.		

P101 Pin	Function			Notes
32 33 34 35	**Roll (aileron) Servo control lines**. These lines cause the stepping motor in the roll servo to run in the appropriate direction at the desired velocity. They are small-signal lines and do not have any substantial current-carrying capability or require any special shielding. Connect to roll servo as shown on wiring diagram.			Reverse servo direction if necessary by swapping wires on pin 32 and 33. See note 3 on wiring diagram.
	Wiring to roll servo J201		Direction of servo arm / capstan rotation (as viewed from face of the servo body) for **RIGHT** aileron	
	J101	Pin 32	Pin 33	
	Standard	J201-4	J201-5	Servo CCW (counter-clockwise) ➔ RIGHT	
	Reversed	J201-5	J201-4	Servo CW (clockwise) ➔ RIGHT	
36	No Connection. Reserved for future expansion.			
37	**Toggle GPSS Mode** with optional externally mounted switch.			GPSS Option Only

Specific connections for certain commonly-used in-panel GPS units

Note that the information in the tables is based upon the best information available from each manufacturer's documentation at the time of publication. Please consult the appropriate installation manual for confirmation of wiring information.

Garmin 430 and 530 connections to TruTrak autopilot			
P4001 [P5001] on Garmin 430 [530]	Signal Name (Garmin)	Signal Name (TruTrak)	P101 on TruTrak Autopilot
56	GPS RS 232 OUT 1	Primary Serial Input	25
46	GPS ARINC 429 OUT A	ARINC-A	26
47	GPS ARINC 429 OUT B	ARINC-B	27

Garmin 430/530 setup instructions:

Power 430/530 up and turn it on while holding down the ENT key. Release the ENT key when the display activates. After the data base pages, the first page displayed is the MAIN ARINC 429 CONFIG page. While in Configuration mode, pages can be selected by ensuring the cursor is off and rotating the small right knob. To change data on the displayed Configuration Page, press the small right knob (CRSR) to turn on the cursor. Turn the large right knob to change between data fields. Turn the large or small right knob to change a field that the cursor is on. Once you have made the desired selection, press the ENT key to accept the entry.

With the MAIN ARINC 429 CONFIG page displayed, on the row labeled OUT, select SPEED ➔ Low and DATA ➔ ARINC 429.

Advance to the MAIN RS232 CONFIG page.

On the row labeled CHNL1, select OUTPUT ➔ Aviation.

Note that for the Garmin units, the autopilot will need to be set for 9600 baud. ARINC 429 steering will only be recognized by the DigiFlight units which have the GPSS option.

UPSAT GX-50/60/65 connections to TruTrak autopilot			
37-Pin Connector on UPSAT GX-50/60/65	Signal Name (UPSAT)	Signal Name (TruTrak)	P101 on TruTrak Autopilot
5 or 22	Use pin 5 – TxD1 – if GX has no GPSS	Primary Serial Input	25
	Use pin 22 – TxD2 – if GX has GPSS		

GX-50/60/65 setup instructions:

Power the GX-50/60/65 up and turn it on while holding down the leftmost and rightmost "smart keys."

Rotate the LARGE knob to the Serial Interface Configuration "CH RX TX" page. Press SEL (the selection fields will start flashing), rotate the LARGE knob to select the port, rotate the SMALL knob to select the desired configurations, then press ENT when complete.

If both the GX unit AND the DigiFlight unit have GPSS capability,
    select "GPSS" for CH 2, Tx column, and wire pin 25 on the DigiFlight to pin 22 of the GX unit

Otherwise
    select "MOVING MAP" For CH 1, Tx column and wire pin 25 on the DigiFlight to pin 5 of the GX unit

To restore the GX-50/60/65 to normal operation, switch its power off, then back on.

Note that for the GX-50/60/65 units, the autopilot will need to be set for 9600 baud. The autopilot's ARINC-A and ARINC-B inputs should be left unconnected, as steering information in the case of UPSAT units is sent over the serial RS232 line along with the ground track and ground speed information the autopilot needs. The serial GPS Steering information is only recognized by DigiFlight units which contain the GPSS Option.

Garmin-35 "Smart Antenna" connections to TruTrak autopilot			
Garmin-35 Wire Color	Signal Name (Garmin)	Signal Name (TruTrak)	P101 on TruTrak Autopilot
Red	PWR	Primary Power	12
Black	GROUND	Ground	19
White	GPS RS 232 OUT 1	Primary Serial Input	25

There is no necessary setup procedure for the Garmin-35 unit. It may require up to 45 minutes to achieve a position fix the first time it is powered on; afterwards it will take less time to obtain a position fix as it contains its own battery and position memory. To use this unit, configure the DigiFlight's baud rate to 4800 baud in the setup screen. This unit does not provide GPSS information, course guidance, or flight planning. Its sole function is to provide the autopilot with a source of ground track and ground speed information to slave the autopilot's internal DG function.

DigiFlight 100 Initial Checkout

Once wiring is completed the autopilot should be tested in the aircraft while on the ground. The first step is to enter the setup mode on the autopilot and set all parameters to their correct values. Apply power to the autopilot programmer.
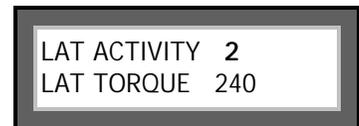
The initial screen should be displayed, along with the words PWR UP in the lower-right of the display. After approximately ten seconds, the autopilot is ready to be set up for operation, indicating AP OFF on the display.

```
MAG 005
        AP OFF
```
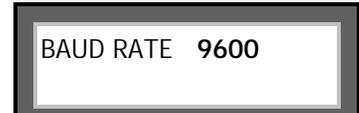
Many of the operations of the autopilot are initiated or confirmed by a press and release of the knob (without rotating it). This is referred to as the ENTER operation. Special setup operations and disengaging of the autopilot are done by holding the knob in for an extended period of time. Any time there is an underlined field showing on the autopilot screen, rotating the knob will cause the underlined active field to change.

Engage the autopilot by pressing ENTER. Then press and <u>hold</u> the knob in for about eight seconds until the first setup screen, showing LAT ACTIVITY and LAT TORQUE is displayed. (During this time the screen will change to indicate "AP OFF" but continue holding in the knob.) Once the activity setup screen is on the display, rotate the knob as necessary to set the lateral activity value to a value of 1 or 2. Press and release the knob to enter that value and advance to the lateral torque field. Insure that the value displayed is somewhere close to the maximum value of 250. Once that is done, press ENTER to enter that value and advance to the next screen.
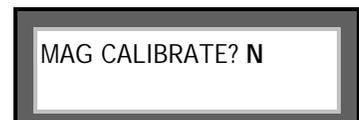
```
LAT ACTIVITY  2
LAT TORQUE   240
```

Rotating the knob, select a value for BAUD RATE which is compatible with the panel-mount GPS receiver connected to pin 25. The value of 9600 is the most commonly used rate. Once baud rate selection is done, press ENTER to enter that value and advance to the next screen.

```
BAUD RATE  9600
```

The next screen gives the option for calibrating the internal backup magnetometer. To the MAG CALIBRATE? Question, answer N (no) at this time. This operation will be done at a later time.

```
MAG CALIBRATE? N
```

Press ENTER. The DigiFlight 100 display will now return to the main screen.

The next step in the check-out procedure is to verify that the servo runs, and in the correct direction. The roll servo should be responding at this time, moving the controls in such a way as to turn the aircraft from the <u>current</u> heading (shown as a 3-digit number after the word MAG in the upper-left of the display) to the <u>selected</u> heading (shown as a 3-digit number after the word SEL in the lower left of the display). The initial value of the selected heading is the current heading of the aircraft at the moment of engagement, but

```
MAG 005
SEL 005   AP ON
```

the knob can be used to modify the selected heading. When the heading shown as SEL agrees with the heading of the aircraft shown in the top line as MAG, the roll servo should stop or run only very slowly. If the knob is rotated clockwise, to a selected heading <u>right</u> of the current heading, the control yoke or stick should move in such a way as to roll the aircraft to the right. Conversely, a selected heading to the <u>left</u> of the current heading will move the controls in the opposite direction to attempt a roll towards the left. If servo direction is not correct, the wires going to pins 4 and 5 of the roll servo (pins 32 and 33 on the main connector) must be reversed to achieve the correct response. If the servo does not move at all, double-check the LAT TORQUE setting to make sure it is at least 240. If a servo jitters but does not actually rotate, check the wiring on the four servo drive lines to that servo for continuity and correctness. If the servo does not seem to have any torque, check the roll torque control line for continuity and correctness.
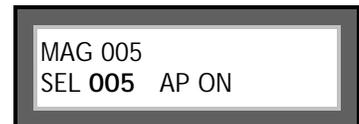
At this time, check that the servo arm or capstan is properly operating the controls. For servo installations using an arm, check that as the controls go from limit to limit the arm of the servo remains in the operating range of the servo (a maximum of 100 degrees total rotation) and that when the controls are centered, the connecting pushrod is approximately perpendicular to the arm of the servo. For capstan systems, insure that the cabling remains at proper tension and is properly secured as the servo moves the controls from stop to stop. Insure that the servo remains secure in its mounting and does not flex its mounting bracket as it drives the control to its stops. For installations using an arm, insure that as the servo moves the control towards the end of control travel it does not cause the main control's torque tube to flex in any way that could cause control system lockup at the extremes of servo travel. Insure that any "lost motion" in the linkages is eliminated or minimized, in order to maximize the performance of the autopilot. Lost motion (dead zone) will result in wandering or slow "hunting" behavior in flight.

The next step in the check-out procedure is to verify that the serial input from the GPS receiver is being properly received and interpreted. With the aircraft outside of any building, power up the GPS panel-mount receiver and the autopilot. After the GPS receiver acquires its position, the autopilot will begin to flash the "*" character once per message from the GPS unit showing that valid position data is available. The display will still show MAG followed by a flashing "*" character, followed by the present approximate magnetic heading. If no "*" is displayed even after it is known that the GPS unit has a position fix, the problem must be diagnosed. Possible reasons for such a problem are,

- Pin 25 on the connector is not wired to a source of RS-232 serial data
- The GPS receiver's baud rate disagrees with that selected within the autopilot
- The GPS receiver's serial output port has not been properly configured to provide the information

The remaining adjustments relate to the dynamics of flight and compensation of the magnetic backup system in the autopilot.

DigiFlight 100 First Flight

The first flight should be done after having completed all the setup and testing on the ground. For the first flight, it is important that the GPS unit is properly functioning with the autopilot, so that the dynamics of flight can be set without consideration of the calibration of the magnetic backup system. As discussed earlier, when there is proper connection to the serial input of the autopilot, the display will show a flashing asterisk "*" in the display to the right of the word MAG; once taxi speed exceeds 10 knots, the display will change from MAG to TRK if the GPS unit has achieved a position fix and sufficient groundspeed. If this does not occur on fast taxi speeds, it is best to diagnose the problem prior to first flight of the autopilot.

The activity adjustment (LAT ACTIVITY) determines how briskly the autopilot responds to roll disturbances. The setting can be adjusted, in flight, over a wide range; thus the autopilot can be tailored to adapt to any aircraft installation.

The activity adjustment covers a numeric range of 0 to 12. Unless the value for a particular aircraft is provided by TruTrak, it is advisable to start with a setting of zero and work up from there. Most installations would ultimately require somewhat higher settings.

On the first flight, manually fly the aircraft to a suitable area for testing. Engage the autopilot by pressing ENTER. Observe that the SEL field now shows the captured present ground track (shown after TRK on the display).

Press and hold the knob for about eight seconds until LAT ACTIVITY is shown on the display, along with an underlined value. Rotate the knob to select the value zero (0), and observe the resulting control movement. Increase the value one setting at a time, taking time to observe an increasing level of control response. At some point, if too high a setting is chosen, the autopilot will be jittery and over-active. Back the setting down until the autopilot is responsive but not over-active. It is best if these adjustments are made in conditions of moderate turbulence (the TruTrak loves turbulence) so as to make it easy to observe the response of the autopilot to disturbances. It will be noted that a fairly limited range of activity setting will be acceptable; too low a value will result in sluggish response, while too high a value will result in nervous, inappropriate response. Within this acceptable range there is room for individual preference; some people prefer a more aggressive autopilot than others. It should be noted that any builder can accomplish this adjustment procedure and no professional is required.

Once the desired LAT ACTIVITY level is established, press ENTER to store the value.

Next, the LAT TORQUE field is adjusted. Again, it is best that this be done in light to moderate turbulence. The reason is that more torque is required of the autopilot in turbulence than is the case in still air, because the velocity of the servo is greater as turbulence requires more rapid servo movement. This means that when activity is set to the high end of the acceptable range, a higher torque setting will be required.

The reason for setting LAT TORQUE to a setting less than its maximum (250) is to reduce the current draw of the servo and to make it easier to override the autopilot should the need arise. Manual override is not normally required, as using the control-wheel switch or the ON OFF button will disengage the autopilot, but it is best to have a setting of torque which can be comfortably overridden if necessary.
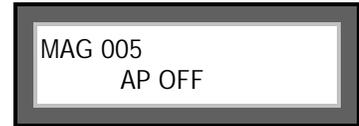
Once the desired LAT TORQUE level is established, press ENTER to store the value. Continue to press ENTER until the main flight screen is back on the display.

Once satisfactory results are obtained in flight dynamic settings, the back-up magnetometer of the autopilot should be calibrated. Proceed to "Magnetic Calibration" for instructions on this operation.

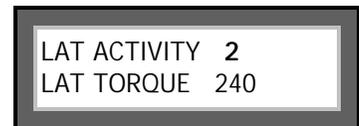## DigiFlight 200 / DigiFlight 200 VS Initial Checkout

Once wiring is completed the autopilot should be tested in the aircraft while on the ground. The first step is to enter the setup mode on the autopilot and set all parameters to their correct values. Apply power to the autopilot programmer.

The initial screen should be displayed, along with the words PWR UP in the lower-right of the display. After approximately ten seconds, the autopilot is ready to be set up for operation, indicating AP OFF on the display.
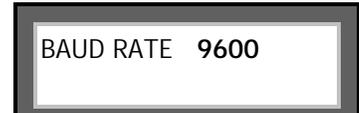
```
MAG 005
        AP OFF
```

Many of the operations of the autopilot are initiated or confirmed by a press and release of the knob (without rotating it). This is referred to as the ENTER operation. Special setup operations and disengaging of the autopilot are done by holding the knob in for an extended period of time. Any time there is an underlined field showing on the autopilot screen, rotating the knob will cause the underlined active field to change.

Engage the autopilot by pressing ENTER. Then press and <u>hold</u> the knob in for about eight seconds until the first setup screen, showing LAT ACTIVITY and LAT TORQUE is displayed. (During this time the screen will change to indicate "AP OFF" but continue holding in the knob.) Once the activity setup screen is on the display, rotate the knob as necessary to set the lateral activity value to a value of 1 or 2. ENTER to enter that value and advance to the lateral torque field. Insure that the value displayed is somewhere close to the maximum value of 250. Once that is done, press ENTER to enter that value and advance to the next screen.

```
LAT ACTIVITY   2
LAT TORQUE   240
```
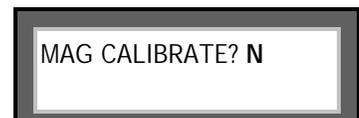
Rotating the knob, select a value for BAUD RATE which is compatible with the panel-mount GPS receiver connected to pin 25. The value of 9600 is the most commonly used rate. Once baud rate selection is done, press ENTER to enter that value and advance to the next screen.

```
BAUD RATE   9600
```

The next screen gives the option for calibrating the internal backup magnetometer. To the MAG CALIBRATE? Question, answer N (no) at this time. This operation will be done at a later time.

Press ENTER.

```
MAG CALIBRATE? N
```

The DigiFlight display will now continue to the next screen, which allows setup for Vertical Activity and Torque. Rotate the knob as necessary to set the vertical activity to a value of 1 or 2. Press ENTER to enter that value and advance to the vertical torque field. Insure that the value displayed is somewhere close to the maximum value of 250. Once that is done, press ENTER to enter that value and advance to the next screen.

```
VRT ACTIVITY   2
VRT TORQUE   240
```
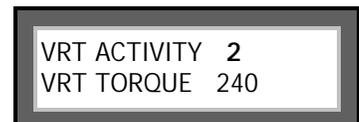
The next screen allows a minimum airspeed to be set. The minimum airspeed value is the slowest indicated airspeed the autopilot will fly, independent of what it is commanded to do. Rotate the knob to adjust this airspeed to a value safely above a stall but lower than normal approach or climbout speeds. Select the desired value, then press ENTER.

```
MIN AIRSPD   90
```

The next screen allows an adjustment for the amount of delay, or "lag" in the aircraft static system. Start with a value of zero until the first flight test of the autopilot. Having verified this selection and set it to zero if necessary, press ENTER. The autopilot will now leave the setup mode and go back to the main screen display.

```
STATIC LAG   0
```

The next step in the check-out procedure is to verify that the servos run, and in the correct direction. At this point, the display differs depending on autopilot model.

DigiFlight 200		DigiFlight 200 VS	

The screen will show that the altitude portion of the autopilot is still disengaged. Press ENTER to engage the altitude hold function.

```
MAG 005
SEL 005   AP ON
```
⇩
```
MAG 005 ALT HOLD
SEL 005   AP ON
```

The lower-right of the screen will show the present value of selected vertical speed, (SVS) which will be approximately zero. Press ENTER to move the cursor to the SVS field, then use the knob to set the value to 0. The display will change to show altitude hold mode.

```
MAG 005
SEL 005 SVS  100
```
⇩
```
MAG 005 ALT HOLD
SEL 005 SVS   0
```

In both cases, the selected heading will be underlined on the bottom left of the display, and the autopilot will be in the altitude hold mode. Both the pitch and roll servos should stop, or move only very slowly.

DigiFlight 200

DigiFlight 200 VS

The autopilot programmer unit needs to be out of the panel, so that it can be gently tipped fore-and aft to simulate nose-up and nose-down flight. If the autopilot is tipped in a nose-down maneuver, the control should move in such a way as to attempt to move the control yoke or stick back, in an effort to raise the nose of the aircraft. Similarly, a nose-up tipping of the autopilot should push the yoke or stick forward in an effort to lower the nose of the aircraft.

Using ENTER will toggle the altitude hold on and off. When the altitude hold is off, the pitch servo is electrically disconnected and will not move in response to disturbances.

With the cursor in the SVS field, rotate the knob clockwise until several hundred feet per minute is showing in the field. At this point, the pitch servo should be moving the control yoke or stick back, in an effort to raise the nose of the aircraft. Similarly, rotating the knob counter-clockwise to select a negative vertical speed (descent) the pitch servo should be moving the controls in such a way as to lower the nose of the aircraft.

Using ENTER will toggle the cursor back and forth between the SVS field and the SEL (selected heading) field. The cursor will revert back to the selected heading field after a few seconds of inactivity.

If the direction of movement of the pitch servo is incorrect, install or remove the jumper between pins 1 and 2 of the autopilot connector and repeat the setup to verify correct results up to this point.

The roll servo should also be responding at this time, moving the controls in such a way as to turn the aircraft from the current heading (shown as a 3-digit number after the word MAG in the upper-left of the display) to the selected heading (shown as a 3-digit number after the word SEL in the lower left of the display). The initial value of the selected heading is the current heading of the aircraft at the moment of engagement, but the knob can be used to modify the selected heading. When the heading shown as SEL agrees with the heading of the aircraft shown in the top line as MAG, the roll servo should stop or run only very slowly. If the knob is rotated clockwise, to a selected heading right of the current heading, the control yoke or stick should move in such a way as to roll the aircraft to the right. Conversely, a selected heading to the left of the current heading will move the controls in the opposite direction to attempt a roll towards the left. If servo direction is not correct, the wires going to pins 4 and 5 of the roll servo (pins 32 and 33 on the main connector) must be reversed to achieve the correct response. If a servo does not move at all, double-check the LAT TORQUE or VRT TORQUE setting as appropriate. If a servo jitters but does not actually rotate, check the wiring on the four servo drive lines to that servo for continuity and correctness. If the servo does not seem to have any torque, check the relevant torque control line for continuity and correctness.

At this time, check that each servo arm or capstan is properly operating the controls. For servo installations using an arm, check that as the controls go from limit to limit the arm of the servo remains in the operating range of the servo (a maximum of 100 degrees total rotation) and that when the controls are centered, the connecting pushrod is approximately perpendicular to the arm of the servo. For capstan systems, insure that the cabling remains at proper tension and is properly secured as the servo moves the controls from stop to stop. Insure that each servo remains secure in its mounting and does not flex its mounting bracket as it drives the control to its stops. For installations using an arm, insure that as the servo moves the control towards the end of control travel it does not cause the main control's torque tube or push-pull tube to flex in any way that could cause

control system lockup at the extremes of servo travel. Insure that any "lost motion" in the linkages is eliminated or minimized, in order to maximize the performance of the autopilot. Lost motion (dead zone) will result in wandering or slow "hunting" behavior in flight.

The next step in the check-out procedure is to verify that the serial input from the GPS receiver is being properly received and interpreted. With the aircraft outside of any building, power up the GPS panel-mount receiver and the autopilot. After the GPS receiver acquires its position, the autopilot will begin to flash the "*" character once per message from the GPS unit showing that valid position data is available. The display will still show MAG followed by a flashing "*" character, followed by the present approximate magnetic heading. If no "*" is displayed even after it is known that the GPS unit has a position fix, the problem must be diagnosed. Possible reasons for such a problem are,

- Pin 25 on the connector is not wired to a source of RS-232 serial data
- The GPS receiver's baud rate disagrees with that selected within the autopilot
- The GPS receiver's serial output port has not been properly configured to provide the information

The remaining adjustments relate to the dynamics of flight and compensation of the magnetic backup system in the autopilot.

DigiFlight 200 / 200VS First Flight

The first flight should be done after having completed all the setup and testing on the ground. For the first flight, it is important that the GPS unit is properly functioning with the autopilot, so that the dynamics of flight can be set without consideration of the calibration of the magnetic backup system. As discussed earlier, when there is proper connection to the serial input of the autopilot, the display will show a flashing asterisk "*" in the display to the right of the word MAG; once taxi speed exceeds 10 knots, the display will change from MAG to TRK if the GPS unit has achieved a position fix and sufficient groundspeed. If this does not occur on fast taxi speeds, it is best to diagnose the problem prior to first flight of the autopilot.

The two activity adjustments (LAT ACTIVITY and VRT ACTIVITY) determine how briskly the autopilot responds to roll and pitch disturbances. They can be adjusted, in flight, over a wide range; thus the autopilot can be tailored to adapt to any aircraft installation.

Each of the two activity adjustments covers a numeric range of 0 to 12. Unless the value for a particular aircraft is provided by TruTrak, it is advisable to start with a setting of zero and work up from there. Most installations would ultimately require somewhat higher settings.

On the first flight, manually fly the aircraft to a suitable area for testing. Press ENTER to engage the autopilot. Observe that the SEL field in the lower-left now shows the captured present ground track (shown after TRK in the upper-left of the display).

DigiFlight 200	DigiFlight 200 VS
Press ENTER to engage Altitude Hold	The SVS field will be showing the approximate rate of climb or descent in feet per minute. Press ENTER to move the cursor to the SVS field, select the value 0 (which will engage altitude hold).

Press and hold the knob for about eight seconds until LAT ACTIVITY is shown on the display, along with an underlined value. Rotate the knob to select the value zero (0), and observe the resulting control movement. Increase the value one setting at a time, taking time to observe an increasing level of control response. At some point, if too high a setting is chosen, the autopilot will be jittery and over-active. Back the setting down until the autopilot is responsive but not over-active. It is best if these adjustments are made in conditions of moderate turbulence (the TruTrak loves turbulence) so as to make it easy to observe the response of the autopilot to disturbances. It will be noted that a fairly limited range of activity setting will be acceptable; too low a value will result in sluggish response, while too high a value will result in nervous, inappropriate response. Within this acceptable range there is room for individual preference; some people prefer a more aggressive autopilot than others. It should be noted that any builder can accomplish this adjustment procedure and no professional is required.

Once the desired LAT ACTIVITY level is established, press ENTER to store the value.

Next, the LAT TORQUE field is adjusted. Again, it is best that this be done in light to moderate turbulence. The reason is that more torque is required of the autopilot in turbulence than is the case in still air, because the velocity of the servo is greater as turbulence requires more rapid servo movement. This means that when activity is set to the high end of the acceptable range, a higher torque setting will be required.

The reason for setting LAT TORQUE to a setting less than its maximum (250) is to reduce the current draw of the servo and to make it easier to override the autopilot should the need arise. Manual override is not normally required, as using the control-wheel switch or holding the knob for three seconds, then releasing it, will disengage the autopilot, but it is best to have a setting of torque which can be comfortably overridden if necessary.

Once the desired LAT TORQUE level is established, press ENTER to store the value.

The BAUD RATE setting has already been done before this flight. Press ENTER to skip to the next screen.

The MAG CALIBRATE function will be done after all other operations. Press ENTER to skip to the next screen.

The screen now displays VRT ACTIVITY along with an underlined value. In the same manner as was done for the roll axis, use the knob to find a setting which results in the appropriate response. Again, too high a value will be jittery or oscillatory and too low a setting will be sluggish and unresponsive. Having found the desired VRT ACTIVITY setting, press ENTER to store the value and move to the VRT TORQUE field.

In a manner similar to the lateral axis, rotate the knob to choose a torque setting sufficient to fly the aircraft in light to moderate turbulence without slipping the servo, yet not so high as to be difficult to override manually. Having selected this value, press ENTER to store the value.

The MIN AIRSPD setting has already been done before this flight. Press ENTER to skip to the next screen.

The next screen is the STATIC LAG field. It is set to 0 at the factory but can vary between 0 and 2 to suit a particular static system. The value 0 assumes a static system with very little "lag"; the value 2 assumes a fairly large amount of lag. To diagnose the lag of a particular system, it is necessary to be in the altitude hold mode of the autopilot, in very still air, in straight-and-level flight. If these conditions cannot be found during the first flight, leave STATIC LAG set to zero. Press ENTER to restore the main flight screen to the display, and perform the operation on a later flight.

To determine the correct setting for STATIC LAG, fly in still air in straight and level flight, in altitude hold mode. Observe whether the altitude appears to oscillate, or "hunt" up and down. If this is the case, it may be caused by several factors, one of which is the amount of lag in the static system. Increasing the STATIC LAG value to a 1 or a 2 may cure the problem; however this should be set to the smallest value that satisfactorily flies the aircraft in the pitch axis, as the larger the value the less responsive the autopilot will be to vertical commands or altitude error. Other possible causes of hunting in altitude hold are "lost motion" in the servo or control linkages or too low a level of vertical activity setting. If there is hunting in altitude, but the lag setting does not seem to make any difference, leave it set at zero. Excessive lag in the static system itself can be caused by undersized static ports, improperly placed ports, long static lines, or especially by attached equipment with large static reservoirs. The autopilot can be adapted to cover a wide range of static systems, but in truly extreme cases it may be necessary to provide a separate static line for the autopilot so that other equipment attached to the port does not degrade the autopilot's performance.

Once satisfactory results are obtained in flight dynamic settings, the back-up magnetometer of the autopilot should be calibrated. Proceed to "Magnetic Calibration" for instructions on this operation.

Magnetic Calibration

The DigiFlight autopilot contains a built-in magnetometer which is used to maintain gyro centering and slaving for the built-in Electronic DG of the autopilot in case of GPS loss. This magnetometer is icalibrated at the factory in a disturbance-free environment, but once installed in the aircraft it may be necessary to account for any magnetic disturbances in the aircraft itself.
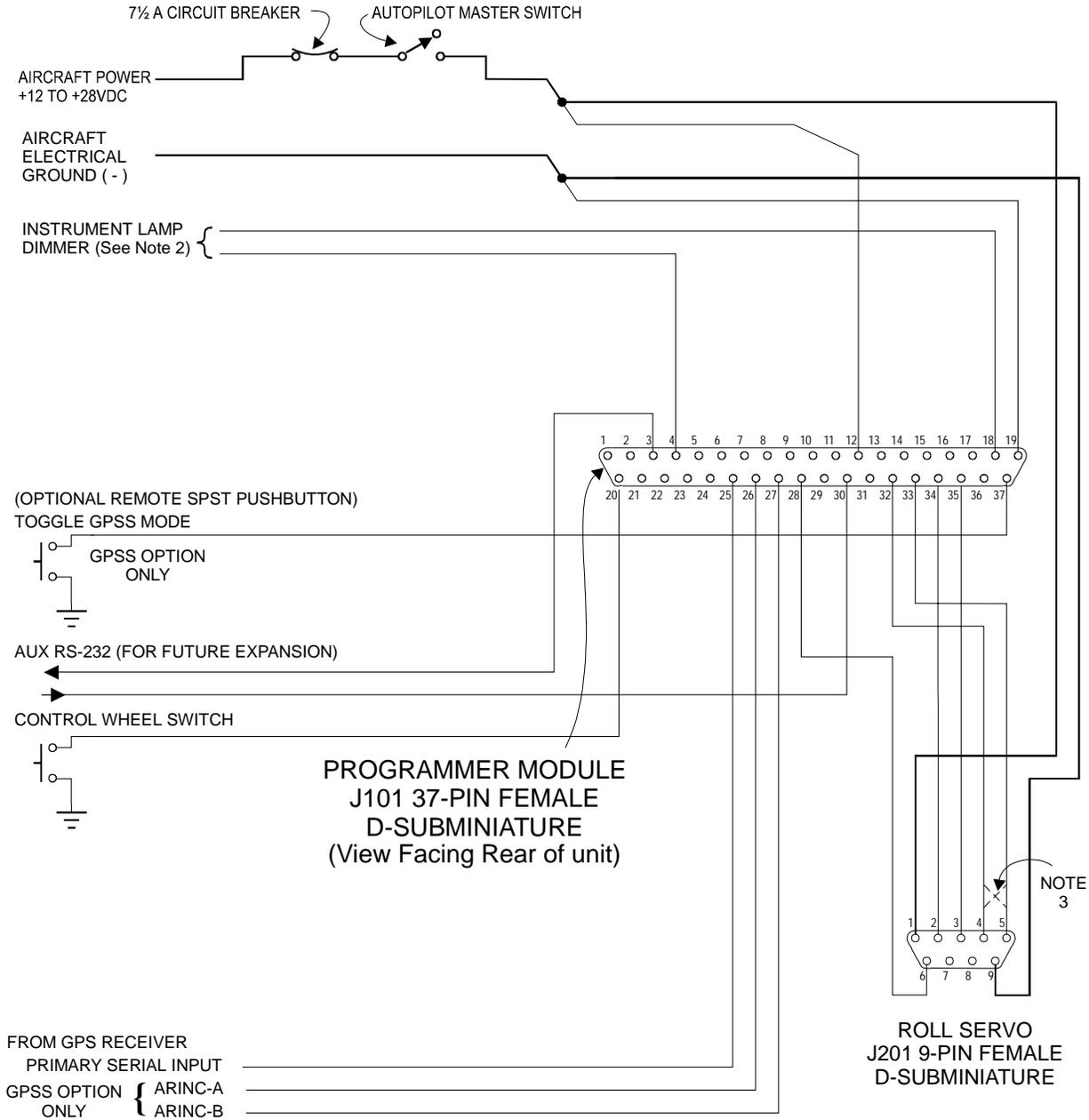
For best results, this operation should be done on a day when the winds are relatively calm, so that air is still and heading and ground track are approximately the same in all directions. The operation should be deferred until such flight conditions exist. For this operation the autopilot will fly four legs of approximately half a minute each, first north, then east, then south, then west. Prior to the calibration sequence, fly the aircraft to an area where this can suitably be done. Verify that the autopilot is receiving GPS properly (note the flashing "*" in the display). Engage the autopilot in its normal tracking (TRK) mode. If the unit is a DigiFlight 200 or 200 VS, engage the altitude hold at an appropriate altitude; if the unit is a DigiFlight 100, the entire calibration sequence needs to be hand-flown in pitch by carefully holding attitude constant during the straight segments of the process.

Once the autopilot is engaged, press and hold MODE until the setup screen appears. Press ENTER to cycle through the activity and baud rate setup screens until MAG CALIBRATE? Appears on the screen. Rotate the knob to select Y (yes) and press ENTER. The autopilot screen will announce "CALIBRATING… TURNING NORTH". It will fly to a ground track of 000 degrees, then say "HOLDING NORTH". For approximately twenty seconds, the unit will obtain data from the magnetometer for this heading. It will then announce "TURNING EAST", then "HOLDING EAST" and so on, until it has flown a twenty-second leg in all four directions, ending up flying towards the west. Having completed this operation, the display will change to "CALIBRATION COMPLETE" "PRESS ENTER". Confirm the calibration sequence by pressing ENTER. At this point, the autopilot will revert back to its normal flight mode with a direction selector, but the upper-left display will show MAG rather than TRK, indicating that the autopilot is in its magnetic backup mode. This allows the mode to be confirmed in flight. Rotate the knob to select various headings and observe the flight of the autopilot in the magnetic backup mode. If problems or innacuracies occur with various headings, it is possible that these problems are due to excessive turbulence or winds on this particular flight, and it may be necessary to repeat the operation at a different time. Once the check-out of the backup mode is finished, disengage and then re-engage the autopilot to return to normal Track (TRK) mode.

This concludes the in-flight setup of the DigiFlight 100 / 200 / 200VS autopilot.
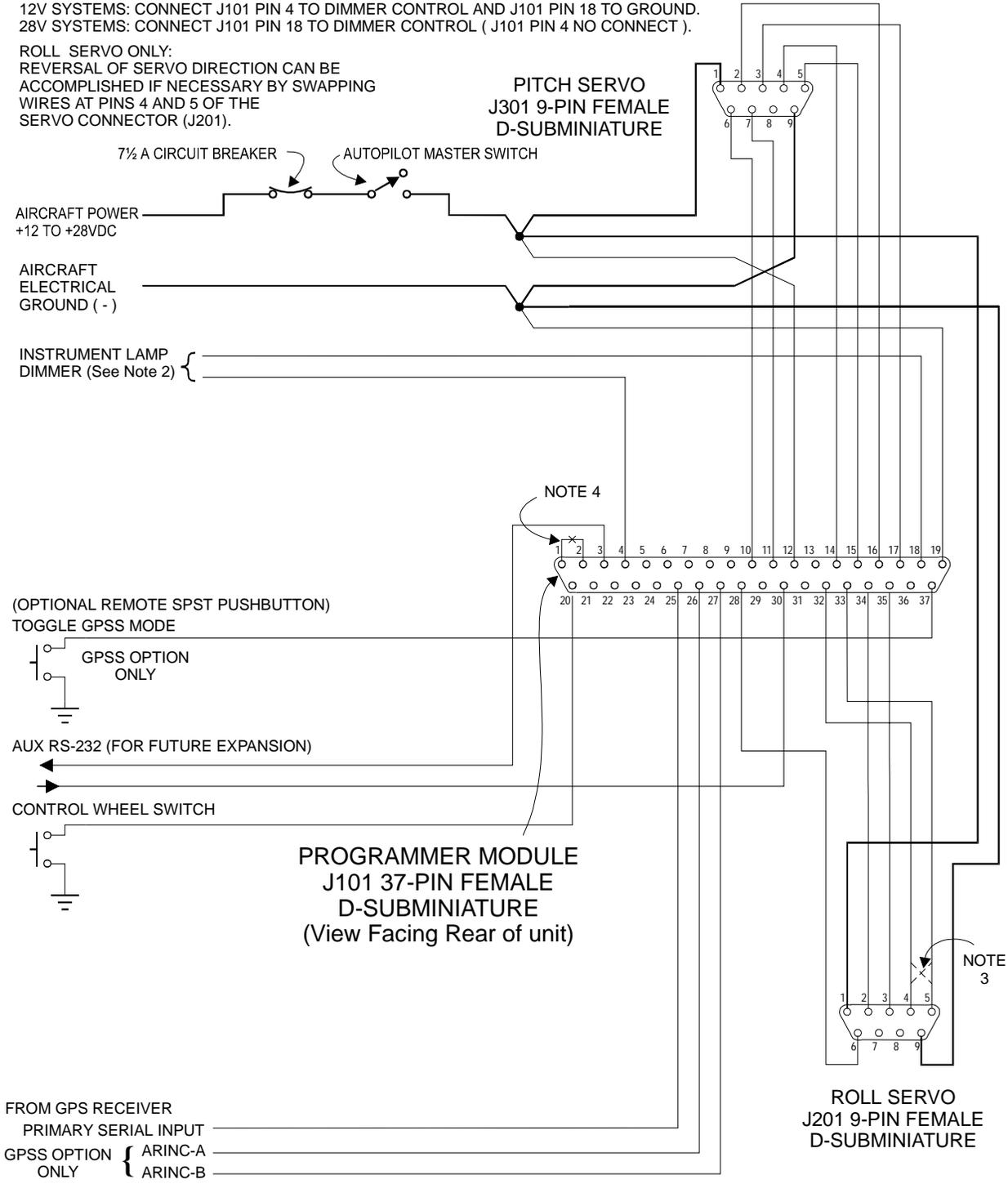
INSTALLATION NOTES:

1. USE #20 AWG FOR POWER AND GROUND WIRES TO SERVO
    (PINS 1 AND 9 ON 9-PIN CONNECTOR J201)
    AND WIRE TO AUTOPILOT MASTER AND SINGLE-POINT GROUND.
    ALL OTHER WIRING #20 TO #24 AWG.

2. INSTRUMENT LAMP DIMMER CONTROL IS OPTIONAL.
    12V SYSTEMS: CONNECT J101 PIN 4 TO DIMMER CONTROL AND J101 PIN 18 TO GROUND.
    28V SYSTEMS: CONNECT J101 PIN 18 TO DIMMER CONTROL (J101 PIN 4 NO CONNECT).

3. REVERSAL OF ROLL SERVO DIRECTION CAN BE
    ACCOMPLISHED IF NECESSARY BY SWAPPING
    WIRES AT PINS 4 AND 5 OF THE
    SERVO CONNECTOR (J201).

7½ A CIRCUIT BREAKER   AUTOPILOT MASTER SWITCH

AIRCRAFT POWER
+12 TO +28VDC

AIRCRAFT
ELECTRICAL
GROUND (-)

INSTRUMENT LAMP
DIMMER (See Note 2)

(OPTIONAL REMOTE SPST PUSHBUTTON)
TOGGLE GPSS MODE

GPSS OPTION
ONLY

AUX RS-232 (FOR FUTURE EXPANSION)

CONTROL WHEEL SWITCH

PROGRAMMER MODULE
J101 37-PIN FEMALE
D-SUBMINIATURE
(View Facing Rear of unit)

NOTE
3

FROM GPS RECEIVER
PRIMARY SERIAL INPUT

GPSS OPTION   ARINC-A
ONLY   ARINC-B

ROLL SERVO
J201 9-PIN FEMALE
D-SUBMINIATURE

DIGIFLIGHT-100 EXTERNAL WIRING DIAGRAM

INSTALLATION NOTES:

1. USE #20 AWG FOR POWER AND GROUND WIRES TO SERVOS (PINS 1 AND 9 ON 9-PIN CONNECTORS J201 AND J301) AND WIRE TO AUTOPILOT MASTER AND SINGLE-POINT GROUND. ALL OTHER WIRING #20 TO #24 AWG.

2. INSTRUMENT LAMP DIMMER CONTROL IS OPTIONAL. 12V SYSTEMS: CONNECT J101 PIN 4 TO DIMMER CONTROL AND J101 PIN 18 TO GROUND. 28V SYSTEMS: CONNECT J101 PIN 18 TO DIMMER CONTROL (J101 PIN 4 NO CONNECT).

3. ROLL SERVO ONLY: REVERSAL OF SERVO DIRECTION CAN BE ACCOMPLISHED IF NECESSARY BY SWAPPING WIRES AT PINS 4 AND 5 OF THE SERVO CONNECTOR (J201).

4. PITCH SERVO ONLY: REVERSAL OF SERVO DIRECTION CAN BE ACCOMPLISHED AS NECESSARY BY INSTALLING OR REMOVING A JUMPER BETWEEN PINS 1 AND 2 OF THE 37-PIN CONNECTOR (CUSTOMER'S J101 MATING PROGRAMMER P101).

PITCH SERVO
J301 9-PIN FEMALE
D-SUBMINIATURE

7½ A CIRCUIT BREAKER   AUTOPILOT MASTER SWITCH

AIRCRAFT POWER
+12 TO +28VDC

AIRCRAFT
ELECTRICAL
GROUND (-)

INSTRUMENT LAMP
DIMMER (See Note 2)

NOTE 4

(OPTIONAL REMOTE SPST PUSHBUTTON)
TOGGLE GPSS MODE

GPSS OPTION
ONLY

AUX RS-232 (FOR FUTURE EXPANSION)

CONTROL WHEEL SWITCH

PROGRAMMER MODULE
J101 37-PIN FEMALE
D-SUBMINIATURE
(View Facing Rear of unit)

NOTE 3

ROLL SERVO
J201 9-PIN FEMALE
D-SUBMINIATURE

FROM GPS RECEIVER
PRIMARY SERIAL INPUT
GPSS OPTION   ARINC-A
ONLY   ARINC-B

DIGIFLIGHT-200 / 200 VS EXTERNAL WIRING DIAGRAM

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