Installation Manual

For

DFC Series Autopilots

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INSTALLATION MANUAL

FOR

DFC-Series Autopilots

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Mechanical Considerations

The installation information in this section is extremely important and must be clearly understood 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 any questions on the part of the installer it is mandatory to resolve these questions prior 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

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, landing light, navigation light, and Pitot heater wiring as far away as possible from any electronics which can be affected by pulsating magnetic fields.

RFI/EMI considerations

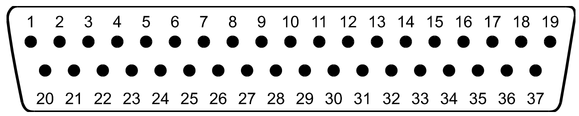
The autopilot programmer is shielded and does not generate any appreciable level of electromagnetic interference. Moreover, the servo lines (except for power and ground) are low-current and cannot contribute to RF interference. The servo power and ground lines do have switching currents through them, 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 inputs to the autopilot are the CDI, Glideslope, and Control Wheel Switch inputs. These lines should not be routed in parallel with transmitting antennas or other sources of known RF interference. If necessary, they can be shielded with the shield connection to pin 19 of the autopilot connector.

Electrical Wiring

All TruTrak DFC series (DFC-200, DFC-200AS, DFC-250, DFC-250AS, DFC-300, DFC-300AS) autopilots have consistent wiring requirements. Therefore, this manual covers all such units, with special notations covering any differences between the units. The DFC-200 programmer is mechanically identical to the DFC-250 and differs only in its internal circuitry and software. The DFC-300 autopilot system consists of a DFC-250 programmer and a YD-300 yaw damper module, together with the three servos that constitute the system.

The table below provides a brief explanation of each pin function on the main 37-pin connector P101.



P101 Autopilot Rear Connector (Viewed from rear of autopilot)

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	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 and six 60 mA lamps. If left disconnected, backlight will be full-on and buttons will be unlighted. Draws approximately 500 mA at 12v, 250 mA at 28v.		Dimmer is wired based on supply voltage. See note 2 on wiring diagram
5	**Yaw Damper Gyro Gain**. A signal from the autopilot which sets the amount of response the yaw damper exhibits to azimuth disturbances.		DFC-300 only
6	**Yaw Damper Tilt Gain**. A signal from the autopilot which sets the amount of response the yaw damper exibits to a given amount of deflection of the "ball".		DFC-300 only
7	No Connection. Reserved for future expansion.		
8	**Yaw Damper Activate**. A signal from the autopilot which turns on the yaw damper function.		DFC-300 only
9	**Analog DG/HSI Input**. A zero to 5V DC signal centered at 2.5 volts from an external steering device. An adapter specific to a given DG or HSI is required. Consult factory for details on this adapter.		
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.		
11	**Pitch Servo Trim Sensor**. A signal from the pitch servo to the autopilot which indicates an out-of-trim condition and its direction.		
12	**Autopilot Master** (+12 to +28 V DC). The autopilot itself draws less than ½ ampere. Most of the current required by the autopilot system is used by the servos (up to 1A per servo).		
13	**Audio alerter signal**. This pin may be wired to an unswitched input of an audio panel. The autopilot uses various tones to denote specific events (loss of GPSS, capture Glideslope, etc). Volume is adjustable within a setup screen of the autopilot.		
14 15 16 17	**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.		Do <u>not</u> attempt to reverse servo direction by swapping wires
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	**CDI LEFT**	Analog +/- 150 mV differential signals from Nav receiver. Pin 22 more positive than pin 21 indicates CDI needle right-of-center.	
22	**CDI RIGHT**		

Autopilot Rear Connections to P101 (Continued)

<table>
<tr><th>P101 Pin</th><th colspan="4">Function</th><th>Notes</th></tr>
<tr><td>23</td><td>GS DOWN</td><td colspan="3" rowspan="2">Analog +/- 150 mV differential signals from Glideslope receiver. Pin 24 more positive than pin 23 indicates GS needle above center.</td><td rowspan="2"></td></tr>
<tr><td>24</td><td>GS UP</td></tr>
<tr><td>25</td><td colspan="4">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.</td><td></td></tr>
<tr><td>26</td><td>ARINC-A</td><td colspan="3" rowspan="2">Digital differential signals from Garmin, Sierra, or other panel-mount receiver which provide directional steering commands (GPSS) to autopilot</td><td rowspan="2"></td></tr>
<tr><td>27</td><td>ARINC-B</td></tr>
<tr><td>28</td><td colspan="4">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.</td><td></td></tr>
<tr><td>29</td><td colspan="4">Localizer mode signal. When floating or at power supply potential, the autopilot will assume CDI signal represents a VOR deviation. When grounded, the autopilot will assume that CDI represents a localizer signal with different flight dynamics, and in addition will allow coupling to the glideslope as well for an ILS approach. Some Nav receivers refer to this as the “ILS Energize” function.</td><td></td></tr>
<tr><td>30</td><td colspan="4">Auxiliary RS-232 Input. Presently unused, intended for future expansion.</td><td></td></tr>
<tr><td>31</td><td colspan="4">No Connection. Reserved for future expansion.</td><td></td></tr>
<tr><td rowspan="5">32
33
34
35</td><td colspan="4">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.</td><td rowspan="5">Reverse servo direction if necessary by swapping wires on pin 32 and 33. See note 3 on wiring diagram.</td></tr>
<tr><td colspan="3">Wiring to roll servo J201</td><td rowspan="2">Direction of servo arm / capstan rotation (as viewed from face of the servo body) for RIGHT aileron</td></tr>
<tr><td>J101</td><td>Pin 32</td><td>Pin 33</td></tr>
<tr><td>Standard</td><td>J201-4</td><td>J201-5</td><td>Servo CCW (counter-clockwise) → RIGHT</td></tr>
<tr><td>Reversed</td><td>J201-5</td><td>J201-4</td><td>Servo CW (clockwise) → RIGHT</td></tr>
<tr><td>36</td><td colspan="4">No Connection. Reserved for future expansion.</td><td></td></tr>
<tr><td>37</td><td colspan="4">No Connection. Reserved for future expansion.</td><td></td></tr>
</table>

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
21	MAIN +LEFT	CDI LEFT	21
22	MAIN +RIGHT	CDI RIGHT	22
27	MAIN +UP	GS UP	24
28	MAIN +DOWN	GS DOWN	23
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
14	ILS / GPS APPROACH	Localizer Mode	29

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.

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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
14	CDI +L	CDI LEFT	21
13	CDI +R	CDI RIGHT	22
5 or 22	Use pin 5 – TxD1 – if GX has no GPSS	Primary Serial Input	25
	Use pin 22 – TxD2 – if GX has GPSS		

<table>
<tr><th colspan="5">UPSAT GX-50/60/65 + SL30 connections to TruTrak autopilot</th></tr>
<tr><th>GX
50/60/65</th><th>SL30</th><th>Signal Name
(UPSAT)</th><th>Signal Name
(TruTrak)</th><th>P101 on
TruTrak Autopilot</th></tr>
<tr><td></td><td>14</td><td>CDI +L</td><td>CDI LEFT</td><td>21</td></tr>
<tr><td></td><td>13</td><td>CDI +R</td><td>CDI RIGHT</td><td>22</td></tr>
<tr><td></td><td>30</td><td>GSI +UP</td><td>GS UP</td><td>24</td></tr>
<tr><td></td><td>31</td><td>GSI +DOWN</td><td>GS DOWN</td><td>23</td></tr>
<tr><td></td><td>33</td><td>ILS ENERGIZE</td><td>Localizer Mode</td><td>29</td></tr>
<tr><td rowspan="2">5
or
22</td><td></td><td>Use pin 5 – TxD1 – if GX has no GPSS</td><td rowspan="2">Primary Serial Input</td><td rowspan="2">25</td></tr>
<tr><td></td><td>Use pin 22 – TxD2 – if GX has GPSS</td></tr>
</table>

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 the GX unit has no GPSS capability, select “MOVING MAP” For CH 1, Tx column and wire to pin 5 of the GX unit;
if the GX unit does have this feature, select “GPSS” for CH 2, Tx column, and wire to pin 22 instead.

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.

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 modes on the autopilot and set all parameters to their correct values. Apply power to the autopilot programmer. Its 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.

Press and hold MODE on the autopilot for about three seconds until the first setup screen, showing LAT ACTIVITY and LAT TORQUE is displayed. Rotate the encoder 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.

Rotating the encoder 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 and release the encoder knob to enter that value and advance to the next screen.

Rotating the encoder knob, select a value for AUDIO VOLUME (0 to 16) which results in a comfortable listening level. This adjustment varies the audio level of the alerter signal output on pin 13 of the programmer and wired into an audio panel. Having selected a comfortable level, press and release the encoder knob to enter that value and advance to the next screen.

Rotating the encoder knob, select Y (yes) or N (no) to the EXT DG/HSI? question. If no external device is connected to pin 9 on the connecter, answer N. The EXT DG flight mode will be present or absent when operating the autopilot based on the answer to this question. Having made this choice, press and release the encoder knob to enter that value and advance to the next screen.

Rotating the encoder knob, select Y (yes) or N (no) to the NAV RCVR? question. If no CDI inputs are connected to pins 21 and 22 on the connector, answer N. The NAV and LOC flight modes will be present or absent when operating the autopilot based on the answer to this question. Also insure that pin 29 is wired to an appropriate signal. Having made this selection, press and release the encoder knob to enter that value and advance to the next screen.

If “Y” (yes) was selected on the NAV RCVR? question the autopilot will then ask whether a glideslope receiver is connected. If no Glideslope deviation inputs are connected to pins 23 and 24 on the connector, answer N. If the question is answered “N” the autopilot will not attempt to couple to a glideslope during localizer approaches. Having made this choice, press and release the encoder knob to enter that value and advance to the next screen.

Rotating the encoder knob, select Y (yes) or N (no) to the YAW DAMPER? question. If no YD-300 module is connected to pins 5,6 and 8 on the connector, answer N. If the programmer is part of the DFC-300 system which includes the yaw damper module, answer Y. Having made this choice, press and release the encoder knob to enter that value and advance to the next screen.

To the MAG CALIBRATE? Question, answer N (no) at this time. This operation can be done at a later time. Press and release the encoder knob to advance to the next screen.

If “Y” (yes) was selected on the YAW DAMPER? question the autopilot will display a setup screen for yaw damper centering and activity settings. At this time, select 0 for YD TILT and 0 for YD ACTIVITY, pressing the knob after setting each value.

Once all the initial lateral setup of the autopilot is complete, the pitch axis initial setup should be done.

Press and hold ALT on the autopilot for about three seconds until the first pitch setup screen is displayed. Rotate the encoder knob as necessary to set the vertical activity value to a value of 1 or 2. Press and release the knob 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 and release the encoder knob to enter that value and advance to the next screen.

The next screen allows a minimum airspeed to be set, as well as (**DFC-250 only**) a default value of climb airspeed for use by the altitude selector. Using the encoder knob, set the minimum airspeed to the slowest airspeed the autopilot should ever fly the aircraft. This should be safely above stall airspeed for the aircraft. This is also the speed (DFC-300 system only) at which the yaw damper will automatically disengage prior to landing. If the system being set up includes a yaw damper, it is necessary to set minimum airspeed to 0 at this time, to allow the yaw damper to be tested properly before the first flight. After selecting the appropriate value(s) press and release the encoder knob to advance to the next screen.

The STATIC LAG field is used to accommodate aircraft with delay in the static line. Start with a value of 0 until the first flight test of the autopilot. Select 0, then press and release the encoder knob to complete the setup mode.

The next step in the check-out procedure is to verify that all servos run, and in the correct direction. Power up the autopilot and wait approximately ten seconds for AP OFF to be displayed in the lower right portion of the screen. Then press and release the ON OFF button to engage the autopilot. At this point, the selected heading will be underlined on the bottom left of the display, while the selected vertical speed ("SVS") will be shown on the bottom right. Use the VS UP and VS DN buttons to set selected vertical speed to zero. The pitch servo should stop, or move only very slowly. Then press VS UP repeatedly until several hundred feet per minute is showing on the lower right SVS 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, using VS DN to select a negative selected vertical speed, the pitch servo should be moving the controls in such a way as to lower the nose of the aircraft. If direction is incorrect, install or remove the jumper between pins 1 and 2 of the autopilot connector.

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 encoder 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 the servos do 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 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

For a DFC-300 system, the next step in the checkout procedure is to verify operation of the yaw damper. Before this test, remove the yaw damper module from its mounting location (a vertical bulkhead) so that it can be manually tilted. Verify the direction strap is correctly wired on pins 16 and 17 of J501, the 25-pin yaw damper connector. If the unit is to be mounted on the rear side of a bulkhead, the strap between pins 16 and 17 of J501 must be absent; if the unit is to be mounted on the front side, the jumper must be present.

Having verified the strap, manually center the rudder and then engage the yaw damper by pressing the MODE key on the autopilot programmer. (Any time the autopilot is off; the yaw damper may be toggled on and off using this key, so long as the aircraft is not flying slower than the preset minimum airspeed). Hold the yaw damper module in the same position it will occupy when mounted on the bulkhead in an approximately level position that stops the servo rotation. Tilt the module to simulate the aircraft banking to the right. The yaw damper should respond by commanding the rudder to move towards the right, and conversely a bank to the left should move the rudder towards the left. If the servo moves in the wrong direction during this test, double-check the correct jumper setting on pins 16 and 17 and if found to be correct, interchange the wires on the yaw damper servo connector (pins 4 and 5 of J401) or at the connector on the yaw damper module (pins 12 and 13 of J501). Re-check the direction after exchanging the wires.

Having verified the correct direction of response to the tilt sensor, secure the yaw damper module to the bulkhead. Re-engage the yaw damper and adjust the leveling potentiometer (which protrudes from the face of the yaw damper module) to stop the movement of the servo. The aircraft should be on a level surface (with its "ball" centered) for this adjustment. Once the proper adjustment is done, press the MODE key to disengage the yaw damper, re-enter the lateral setup using the MODE button, and set YD ACTIVITY value to zero. This insures that the yaw damper adjustments do not complicate the first test flight of the autopilot. Holding down the ALT button to enter the setup mode, and repeatedly pressing ENTER to advance to the MIN AIRSPD field, set the minimum airspeed to the desired value for actual flight. This should be an indicated airspeed (in knots) which is safely above the stall but not below normal approach or climbout speeds.

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

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.

Prior to takeoff on the first flight, synchronize the autopilot's altimeter to the aircraft's primary altimeter value. With the autopilot off press the ALT button once, to show the ALTIMETER SYNC screen (take care not to accidentally enter the ALT SELECT screen by mistake). Use the encoder knob to adjust the altitude reading to agree. Each click of the knob gives 100 foot increments; to get ten-foot increments, push in on the knob and rotate it. Having set the autopilot's altimeter to agree with the primary altimeter, press ENTER to record this value.

On the first flight, manually fly the aircraft to a suitable area for testing. Engage the autopilot using the ON OFF switch. Observe that the SEL field now shows the captured present ground track (shown after TRK on the display) and the SVS (<u>s</u>elected <u>v</u>ertical <u>s</u>peed) field shows the approximate present rate of climb or descent in feet per minute. Use the VS UP or VS DN buttons to set the selected vertical speed to zero. Press and hold the MODE button for a few 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 <u>loves</u> 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.

Having set the autopilot for its proper roll response, it is time to move to the pitch axis adjustments. Press and hold the ALT button until VRT ACTIVITY is shown on the display, 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 next screen shows selections for MIN AIRSPD and NORM CLIMB. The minimum airspeed value is the slowest indicated airspeed the autopilot will fly, independent of what it is commanded to do. This airspeed value should be safely above stall speed (knots IAS) yet slower than normal approach or climbout speeds. Select the value, and press ENTER to confirm it. The NORM CLIMB field is the airspeed (knots IAS) which would be normally used in a climb, typically the cruise climb airspeed for the aircraft. This value shows up as the default airspeed (which can be changed as desired while climbing) in the altitude selector function. Select the normal climb airspeed with the knob and press ENTER to confirm and store the value.

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, so prior to setting this field, simply press the ALT button, cycling the vertical mode display until the ALTITUDE HOLD screen shows, then press ENTER. This puts the autopilot into altitude hold mode at the current altitude.

Once the autopilot is in altitude hold mode, re-enter the vertical setup mode by holding the ALT key. Use the knob's ENTER function to cycle over the choices already made until the STATIC LAG display is again on the screen. In still air, 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 aircraft controls or too low a level of vertical activity setting. 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.

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 calibrated 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.

Once satisfactory results are obtained in flight dynamic settings, the back-up magnetometer of the autopilot should be calibrated. 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. Engage the autopilot and select the altitude hold mode at an appropriate altitude. Press and hold MODE until the setup screen appears. Press ENTER to cycle through the previously-done settings 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 <u>magnetic</u> <u>backup</u> <u>mode</u>. 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 inaccuracies 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.

DFC-300 systems require adjustment of the yaw damper parameters. With the autopilot disengaged, level the aircraft and hand-fly the aircraft in still air. Press MODE to engage the yaw damper (the lower-left part of the display will indicate YD ON). Then press and hold MODE to enter the setup screen. Cycle through the settings already done until YD LEVELING and YD ACTIVITY show on the display. Centering is adjustable from -8 to 8 and has enough authority to move the ball approximately one and one half times the width of the ball in either direction. (Coarse adjustment was made using the potentiometer in the yaw damper module during the earlier Initial Checkout Procedure.) The next field, YD ACTIVITY, determines how aggressively the yaw damper responds to yaw disturbances. Yaw damper activity can range from 0 (off) to 12 (extremely aggressive). For this purpose it is best to find light to moderate turbulence so the effects can be properly observed. Having found suitable conditions, use the knob to gradually increase the value of YD ACTIVITY in order to obtain an appropriate level of response to yaw disturbances. Too high a value will result in rapid oscillation, while too low a value will essentially disable the quick response of the yaw damper to turbulence. Within the acceptable range of operation, there is still room to account for personal preferences. So long as the yaw damper's YD ACTIVITY value is not so high as to cause oscillation, the response is simply set according to preference and comfort.

The normal operation of the autopilot will turn the yaw damper on any time the autopilot is engaged, and the yaw damper will <u>stay</u> on after the autopilot is disengaged. During final approach and the diminishing of the airspeed below the MIN AIRSPD setting, the yaw damper will automatically disengage. To disengage the yaw damper prior to that point, simply use the MODE button to toggle the yaw damper off. When the autopilot is in the Off mode, the MODE button acts as a yaw damper on/off toggle function and the display will indicate YD ON or YD OFF.

This concludes the in-flight setup of the TruTrak digital autopilot.

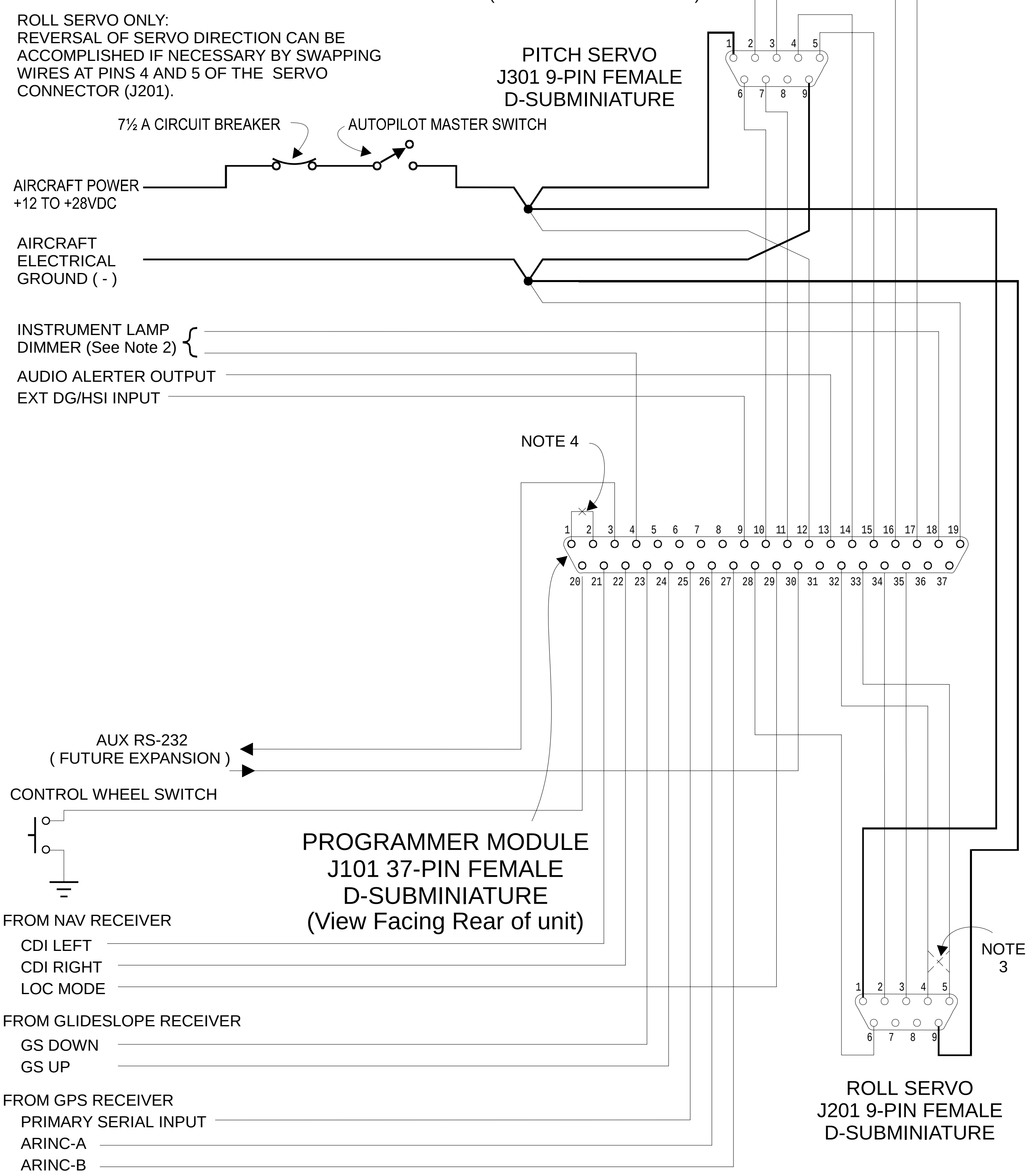
INSTALLATION NOTES:

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).



DFC-200/250 EXTERNAL WIRING DIAGRAM

INSTALLATION NOTES:

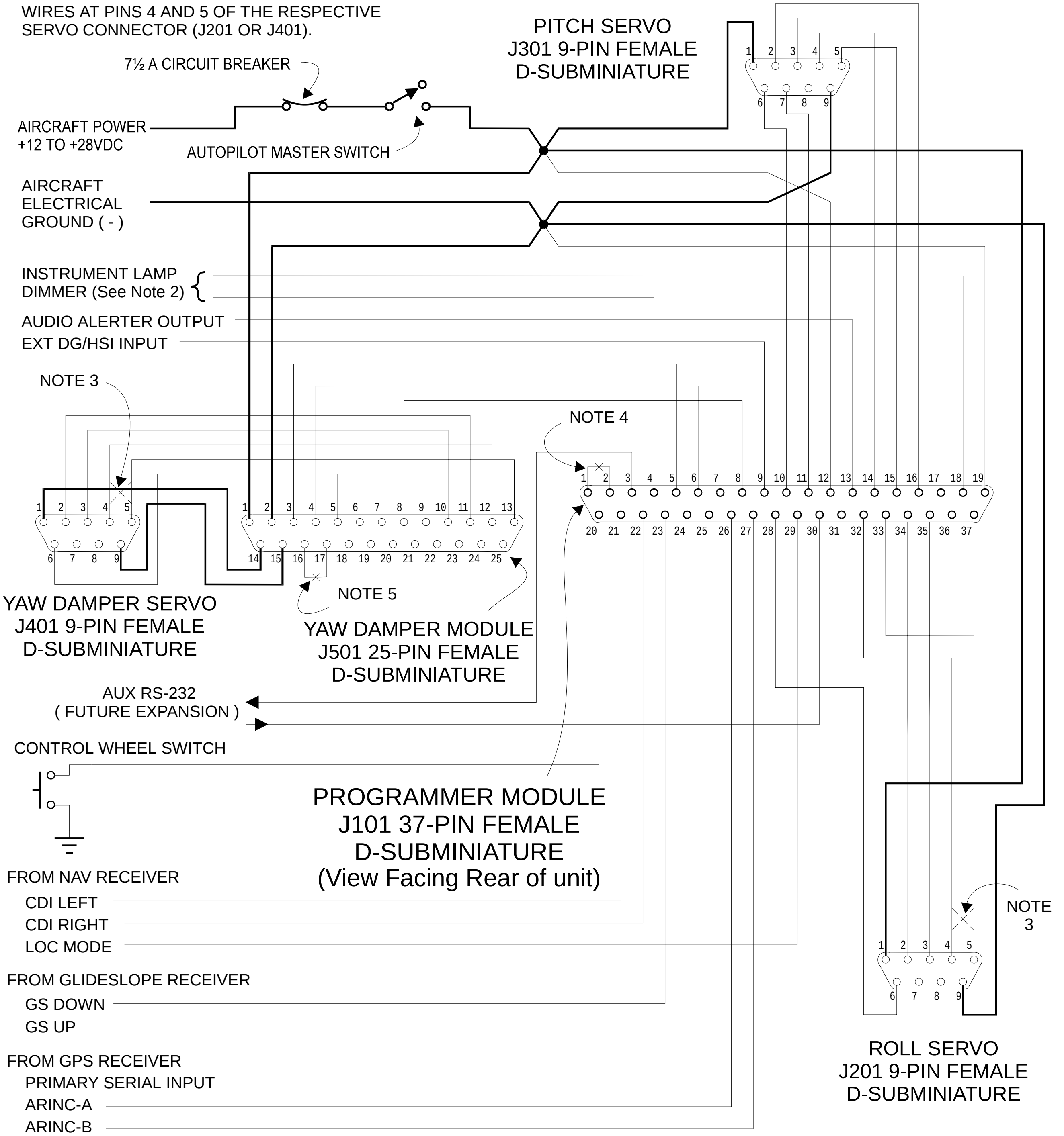
1. USE #20 AWG FOR POWER AND GROUND WIRES TO SERVOS (PINS 1 AND 9 ON 9-PIN CONNECTORS J201, J301 AND J401) AND WIRE TO AUTOPILOT MASTER AND SINGLE-POINT GROUND. ALL OTHER WIRING #20 TO #24 AWG.

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 AND YAW DAMPER SERVOS ONLY: REVERSAL OF SERVO DIRECTION CAN BE ACCOMPLISHED IF NECESSARY BY SWAPPING WIRES AT PINS 4 AND 5 OF THE RESPECTIVE SERVO CONNECTOR (J201 OR J401).

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).

5. YAW DAMPER UNIT MUST BE MOUNTED ON A VERTICAL TRANSVERSE BULKHEAD. JUMPER IS INSTALLED ONLY IF MODULE IS MOUNTED ON BULKHEAD FRONT SIDE.



DFC-300 EXTERNAL WIRING DIAGRAM

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