

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



CEN23LA014

SYSTEMS

Group Chair's Factual Report

July 22, 2024

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A. ACCIDENT

Location: Dallas, TX
Date: October 15, 2022
Time: 1448 central daylight time (CDT)
1948 universal coordinated time (UTC)
Airplane: Diamond DA-62, N84LT, 62.C003

B. SYSTEMS GROUP

Group Chair	John Flynn National Transportation Safety Board (NTSB) Washington, DC
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C. SUMMARY

On October 15, 2022, at about 1448 central daylight time, a Diamond Aircraft DA-62, N84LT, was substantially damaged during a forced landing near Dallas Executive Airport (RBD), Dallas, Texas. The pilot and passenger were not injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

A review of air traffic control (ATC) flight track data revealed the airplane departed Winston Field Airport (SNK), Snyder, Texas, about 1332 and climbed to a cruise altitude of 11,500 ft mean sea level (msl). The pilot descended to fly a visual approach to Runway 13 at RBD, lowered the landing gear, and contacted the tower controller for landing clearance.

During the controller's response, the pilot reported hearing a "pop" and observed the avionics display screens lose power. A few seconds later, he observed both engines had lost power. The pilot executed a forced landing onto an urban road, during which the airplane struck a power line and road sign that resulted in substantial damage to the right wing.

The initial review of the downloaded engine and flight data indicated the airplane lost electrical power to the avionics system and both engines nearly simultaneously, while at 2,000 ft msl and about 5 miles west of RBD.

D. AIRCRAFT INFORMATION

An external view of a DA-62 is shown in Figure 1. The DA-62 is a twin-engine, five seat, low wing mono-plane. It has a cantilever wing and a 'T' tail. The semi-monocoque fuselage is a carbon-fiber reinforced-plastic (CFRP) shell with glass-fiber reinforced-plastic (GFRP) bulkheads and stiffeners. The fuselage is constructed in 2 halves that are bonded together after installation of the fuselage bulkheads and frames. Carbon fiber is used in many areas to give increased strength and rigidity. A roll-over protection bar forms part of the construction of the cockpit area. The vertical stabilizer is integral with the fuselage shells.

A wing center section is attached to the bottom of the fuselage center section. The wing center section has the 2 engine nacelles, the wing stubs, and the fuselage center-section floor. The engine nacelles give the fixing points for the engines. The wing stubs have the attachment points for the outer wings. The cantilever outer wing is a semi-monocoque structure. Each wing has two I-shaped spars with webs made from GFRP/rigid foam sandwich and caps made from CFRP tapes. Electrically operated flaps and mechanical ailerons are attached to the trailing edge of the wings.

The horizontal stabilizer is a semi-monocoque structure. It has top and bottom shells made of GFRP and CFRP with two main spars. The shells are bonded to the spars and ribs. The trailing edge has a conventional elevator with both mechanical and electrical trim systems.

The tricycle landing gear is fully retractable and hydraulically operated. The main landing gear legs are attached to mounting points in the wing center-section. The main landing gear retracts into integral compartments in the wing center section. Landing gear doors seal the landing gear bays when the gear is retracted. The nose landing gear is steerable and is attached to the lower front of the fuselage. The nose landing gear bay is integral with the front fuselage and doors seal the bay when the gear is retracted.

The flight control system uses conventional ailerons, elevator, and rudder. The DA-62 has 2 control sticks and 2 rudder pedal assemblies to operate the primary flight controls. Push-pull rods operate the ailerons and the elevator. Cables operate the rudder. An electric motor operates the flaps via push-pull rods. The elevator has both an electric and a manual trim system. A handwheel and Bowden cable operate the elevator trim mechanically. The rudder has a mechanical trim system which uses a rotary drive and Bowden cable to operate a rudder trim tab.

Two Austro Engine E4P-C liquid-cooled, in-line four-stroke four cylinder engines with double overhead camshaft (DOHC) with four valves per cylinder. The valves are actuated by the cam follower. The direct fuel injection is realized by means of a common rail technique and the engine is charged by a turbo charger in combination with an intercooler. The propeller is activated by an integrated gearbox with an integral torsional vibration damper. All engine components are controlled by an electronic engine control unit (EECU) system.

The airplane has aluminum fuel tank assemblies in each wing. Each fuel tank has 3 chambers which are mounted between the wing spars. The outer fuel chamber of each assembly has a fuel filler. Flexible hoses connect the fuel tanks to the fuel distribution system. Each tank can feed either engine via a fuel crossfeed system. Fuel level sensors are installed in the inner and outer fuel tank chambers. The fuel level sensors control the fuel indicating system in the cockpit. Auxiliary fuel tanks made of polyethylene plastics are optionally installed.

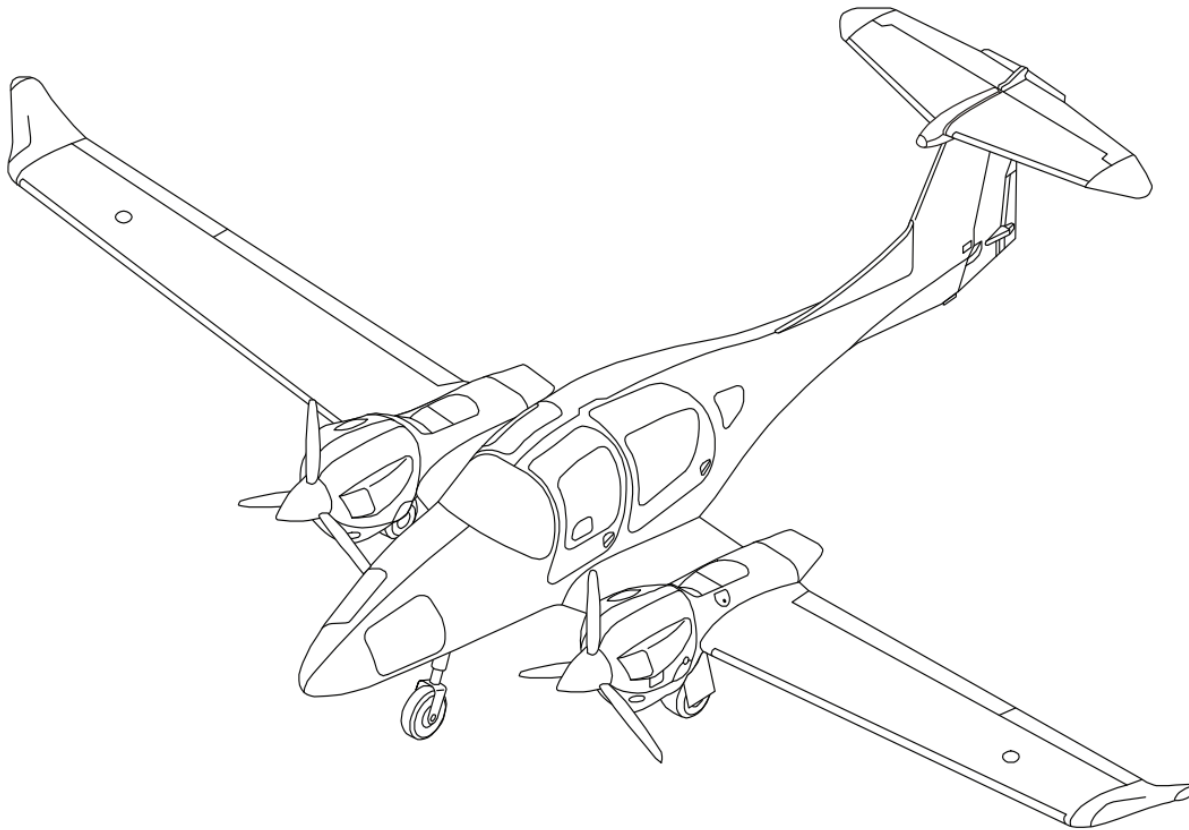


Figure 1. DA-62 airplane. (Courtesy of Diamond Aircraft)

1.0 Electrical System

The DA-62 has a 24 volt direct current (VDC) electrical system which can be divided into power generation, storage, distribution, and consumers. Simplified schematics of the electrical system are shown in Figures 2 and 3. Flight deck switches are shown in Figure 4.

1.1 Power Generation

Power generation is provided by two 70 ampere (Amp) alternators (generators) which are mounted on the bottom left side of each engine. The alternators are driven by a flat belt. The power output line of the left hand (LH) alternator is connected to the LH main bus via the LH alternator relay and a 60 ampere circuit breaker (CB). The power output line of the right hand (RH) alternator is connected to the RH main bus via the RH alternator relay and a 60 ampere CB. Both main buses are connected to the battery bus via a 90 ampere CB. The accident aircraft also included an optional third alternator that is installed on the LH engine and only powers an air conditioning system.

Both alternator power output lines also run through a current sensor which displays the current on the engine page on the multi-function display (MFD). This provides an indication of the power being supplied to the electrical system, including the current used for battery charging, by each alternator. In the event of a main battery failure, the field of each alternator is energized by two 12 V, 7.2 amp hour (Ah) sealed lead acid batteries (also known as the engine control unit (ECU) backup batteries) connected in series, which are installed under the passengers' seats. The ECU backup batteries provide electrical power for the ECU and the engine fuel pump for a time of 30 minutes.

The LH and RH engine master switches connect the ECU backup batteries to their respective alternator field via a 10 ampere fuse.

1.1.1 Alternator Control

Each alternator has an alternator control unit. It measures the alternator output voltage and controls the current through the alternator field coils via a pulse-width modulated signal. To keep the output voltage stable in all load and speed situations, the alternator field signal is modulated accordingly.

The left alternator regulator also measures the power output of both (LH and RH) alternators via separate current sensors. Based on the current measurements, the LH alternator regulator controls the output of its associated alternator, providing paralleling between the alternators.

The alternator control unit includes a comprehensive set of diagnostic functions that will warn the operator using a caution message (L/R ALTN FAIL) on the primary flight display (PFD) in case of over- or undervoltage as well as a couple of other internal warning messages.

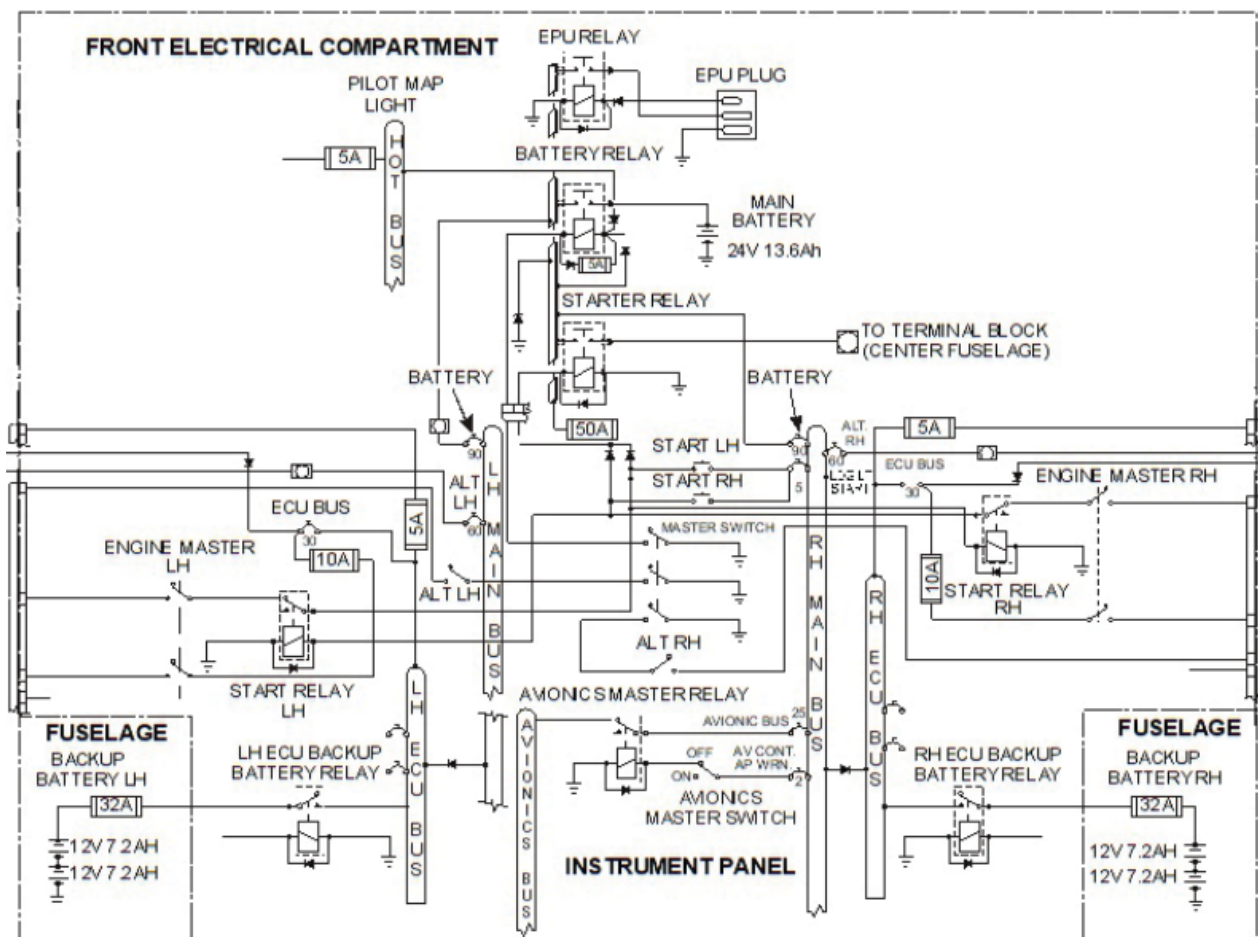


Figure 2. DA-62 simplified electrical schematic - sheet 1. (Courtesy of Diamond Aircraft)

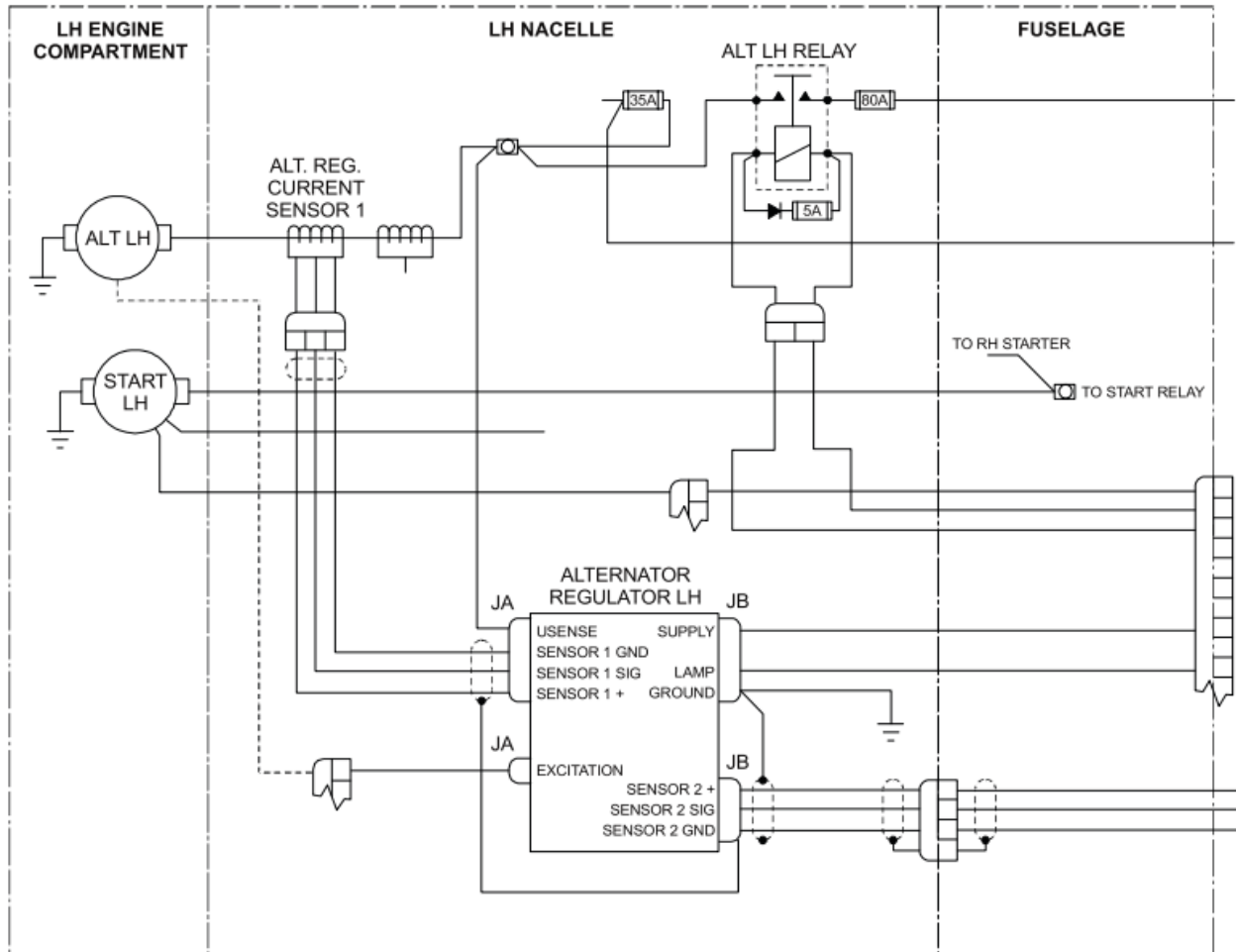


Figure 3. DA-62 simplified electrical schematic - sheet 2. (Courtesy of Diamond Aircraft)



Figure 4. DA-62 flight deck switches.

1.2 Storage

Main battery power is stored in a 24 V, 13.6 Ah lead-acid battery mounted on the right-aft side of the front electric / avionic compartment. The main battery is connected to the hot battery bus; and to the battery bus via the battery-relay which is installed in the relay junction box on the forward side of the front electric / avionic compartment.

The battery relay is controlled with the electrical master switch which is located on the left-hand side of the instrument panel.

1.3 Distribution

Electrical power is distributed via the hot battery bus, the battery bus, the LH (RH) ECU buses, the LH (RH) main buses, and the avionic bus.

1.3.1 HOT BATTERY BUS

The hot battery bus is directly connected to the main battery and cannot be disconnected from the main battery. The hot battery bus provides power to the pilot map/reading light which is protected by its own fuse.

1.3.2 BATTERY BUS

The battery bus is connected to the main battery via the battery relay which can be controlled by the electrical master switch. The battery bus provides power to the LH (RH) main buses and heavy duty power to both starters.

1.3.3 ECU BUS

The LH (RH) ECU buses are connected to the LH (RH) main buses via a diode and connected to the power output line of the alternator via diode and a 30 ampere CB and provides power directly to ECU A and its fuel pump. ECU B and its fuel pump derive their electrical power from their associated ECU bus via an additional diode and fuse.

The LH (RH) engine master switch must be set to ON to activate the engine ECU. To support the alternator electrical power supply to the ECUs in case of a malfunction of the main battery, additional sealed-lead-acid batteries (ECU backup battery) are connected to the RH and LH ECU buses.

These batteries are designed to provide 30 minutes of engine operation in case of a complete airplane electrical failure. Both engines may stop if the 30 minutes have elapsed.

1.3.4 MAIN BUS

The LH (RH) main buses are connected to the battery bus via a 90 ampere CB. The LH main bus provides power to the consumers directly connected to the LH main bus. The RH main bus provides power to the consumers directly connected to the RH main bus and the avionic bus via the avionics master relay.

The avionic master switch must be set to ON to connect the RH main bus to the avionic bus.

1.4 Consumers

The individual consumers (e.g., radio, position lights, etc.) are connected to the appropriate bus via automatic CBs. According to the electrical load analysis (ELA), the largest single power demand is the landing gear hydraulic pump at 42 amps.

2.0 Engines

There are two Austro Engine E4P-C engines installed, which have the following specifications:

- Liquid-cooled four-cylinder four-stroke engine with wet sump lubrication

- Inline construction
- Common rail direct injection
- Propeller speed reducing gear 1:1.69
- Digital engine control with integrated propeller governor (separate oil system)
- Turbo charger with intercooler

The important engine parameters can be monitored during operation using the integrated Garmin G1000 display. Each engine can only be operated with the engine master switch ON. Each engine has its own ECU which receives its electrical power from the generator when at least one engine is running. When both engines are off, the ECU receives its electrical power from the battery.

2.1 PROPELLER

Two hydraulically regulated 3-bladed constant speed feathering propellers are installed. Each propeller has wood composite blades with fiber-reinforced plastic coating and stainless steel edge cladding.

2.1.1 Propeller Control

The propeller pitch control system consists of a propeller governor valve. The pitch is set by the ECU via an electro-mechanical actuator on the governor. To change the blade pitch angle gearbox oil is pumped into the propeller hub. Increasing the oil pressure leads to a decrease of pitch and higher revolutions per minute (RPM). Decreasing the pressure leads to higher pitch and a lower RPM. Depending on the power lever setting the propeller pitch is adjusted such that the required RPM will be obtained.

2.1.1.1 Pressure Accumulator

The pressure accumulator is a nitrogen oil type. It is connected to the gearbox oil circuit via an electric valve at the accumulator, which is operated with the engine master switch.

When the engine master switch is set to ON the valve is opened. During engine operation the accumulator makes sure that enough oil pressure is available even if the oil feed by the gearbox oil pump is decreasing due to negative acceleration. The hydraulic pressure keeps the propeller pitch angle below the start lock position or moves the propeller blades beyond the start lock position.

2.1.1.1 Feathering

To feather the propeller the engine must be shut down with the appropriate engine master switch. This will open the electric governor valve. All oil will flow back

from the propeller hub, allowing the blades to move into the feathered pitch position. At the same time the electric valve at the pressure accumulator closes, and the oil pressure is restored in the accumulator. Feathering is only possible at propeller speeds above 1300 RPM.

2.1.1.1 Unfeathering

To unfeather the propeller, the associated engine master switch must be set to ON. This will open the electric valve at the pressure accumulator. The pressure stored in the accumulator will move the propeller blades into a low pitch position. As soon as the propeller starts turning and the gearbox oil operates, the accumulator will be refilled.

2.2 Power Lever

Engine performance is controlled by a power lever for each engine. Both power levers are situated on the large center console. Each power lever is used to set the desired engine power LOAD (%)

- Lever forward¹ (MAX) = Full power
- Lever to rear (IDLE) = Idle

A separate ECU for each engine controls manifold pressure, injected fuel quantity and propeller speed according to the desired engine power preselected with the power lever.

2.3 Electronic Engine Control Unit (EECU)

The electronic ECU is used to control the engine actuators (e.g., fuel injectors) according to the engine sensor information. The ECU monitors, controls and regulates all important parameters for engine operation.

Sensors installed are:

- Oil temperature (lubrication system engine) / OIL TEMP
- Oil pressure (lubrication system engine) / OIL PRES
- Coolant temperature / COOLANT TEMP
- Gearbox oil temperature / GEARBOX
- Camshaft RPM (x2)
- Crankshaft RPM (x2)
- Fuel pressure in the common rail
- Manifold pressure
- Manifold air temperature (x2)
- Ambient air pressure (x2)
- Propeller governor
- Power lever position (twice)

¹ Forward and rear are defined in relation to the direction of flight.

- Voltage
- Starter switch signal
- Fuel pressure
- Voter switch signal
- ECU test switch signal

Based on the received signals and a comparison with the programmed characteristics, the ECU calculates the necessary inputs and transmits them to the following components on the engine:

- Propeller governor pressure valve
- Fuel metering unit
- Each of the 4 injection nozzles
- Glow plugs
- Waste gate valve

The following alerts are displayed on the PFD:

- Glow sparks active
- Status ECU A
- Status ECU B
- Low fuel pressure

The electronic ECU consists of two ECUs per engine. A voter switch is integrated in the electronic ECU and proposes (if set to AUTO) an ECU to control the engine regarding the ECU operating hours or in case of a failure the ECU with better engine control capability. If the voter switch is set to A (ECU A) or B (ECU B), the related ECU is forced to control the corresponding engine.

A fault detected by the ECUs is indicated by a caution message on the PFD (L/R ECU A/B FAIL). The faults can result in a latched caution indication or a non-latched indication.

2.3.1 ECU VOTER

There are two voter switches, one for each engine. For normal operation both switches are set to AUTO. Each engine is controlled by either ECU A or ECU B. In case of a failure of the active ECU there should be an automatic switch-over to the other ECU. If the automatic switch over fails, switch over can be done manually by switching to ECU A or ECU B.

2.3.2 ECU TEST

There are two ECU test buttons, one for each engine. With the power lever at idle and propeller RPM below approximately 900 RPM, the ECU test can be initiated.

The self-test of each engine control unit is performed by pushing and holding the button until the end of the procedure. The procedure is possible on the ground only. During the procedure, the ECU performs a switch from ECU A to ECU B or ECU B to ECU A, whichever is active at the moment, with the propeller cycling. The propeller RPM is monitored automatically by the ECU. When switching from one ECU to the other, a slight shake of the engine may occur. Finally, the ECU switches back to the ECU channel that was originally in control. After that both caution lights must extinguish, and the engine must run without a change in RPM.

3.0 Hydraulics

The hydraulic main unit contains all components which are necessary to produce the hydraulic power for the DA-62. It consists of the hydraulic pump, the hydraulic fluid tank, the hydraulic main control block and the hydraulic accumulator (Figures 5 and 6).

The hydraulic pressure for the landing gear operation is provided by an electrically powered hydraulic pump, which is activated by a pressure switch, when the required pressure is too low. Electrically actuated hydraulic valves, which are operated with the gear selector switch, provide the required hydraulic pressure for the movement of the landing gear. The gear selector switch is located on the instrument panel. The switch must be pulled out before it is moved to the UP or DOWN position. Gear extension normally takes 6-10 seconds.

When the landing gear is retracted, the main wheels retract inboard into the center wing and the nose wheel retracts forward into the nose section. Hydraulic pressure on the actuators keeps the landing gear in the retracted position. A pressurized gas container acts as an accumulator which keeps the system pressure constant by replacing the volume lost due to the normal actuator leakages. This prevents continuous operation of the hydraulic pump in flight.

Springs assist the hydraulic system in gear extension and locking the gear in the down position. After the gears are down and the downlock hooks engage, springs maintain force on each hook to keep it locked until it is released by hydraulic pressure.

The three green lights directly next to the landing gear operating switch illuminate to indicate that each gear is in the correct position and locked. If the gear is in neither the full up nor the full down position, a red warning light on the instrument panel illuminates. Should one power lever be placed in a position below 25% while the landing gear is retracted, a warning horn sounds to alert the pilot that the gear is retracted. Additionally, a CHECK GEAR caution is indicated on the PFD. The same warning appears if the flaps move into LDG position (fully extended) while the gear is

retracted.

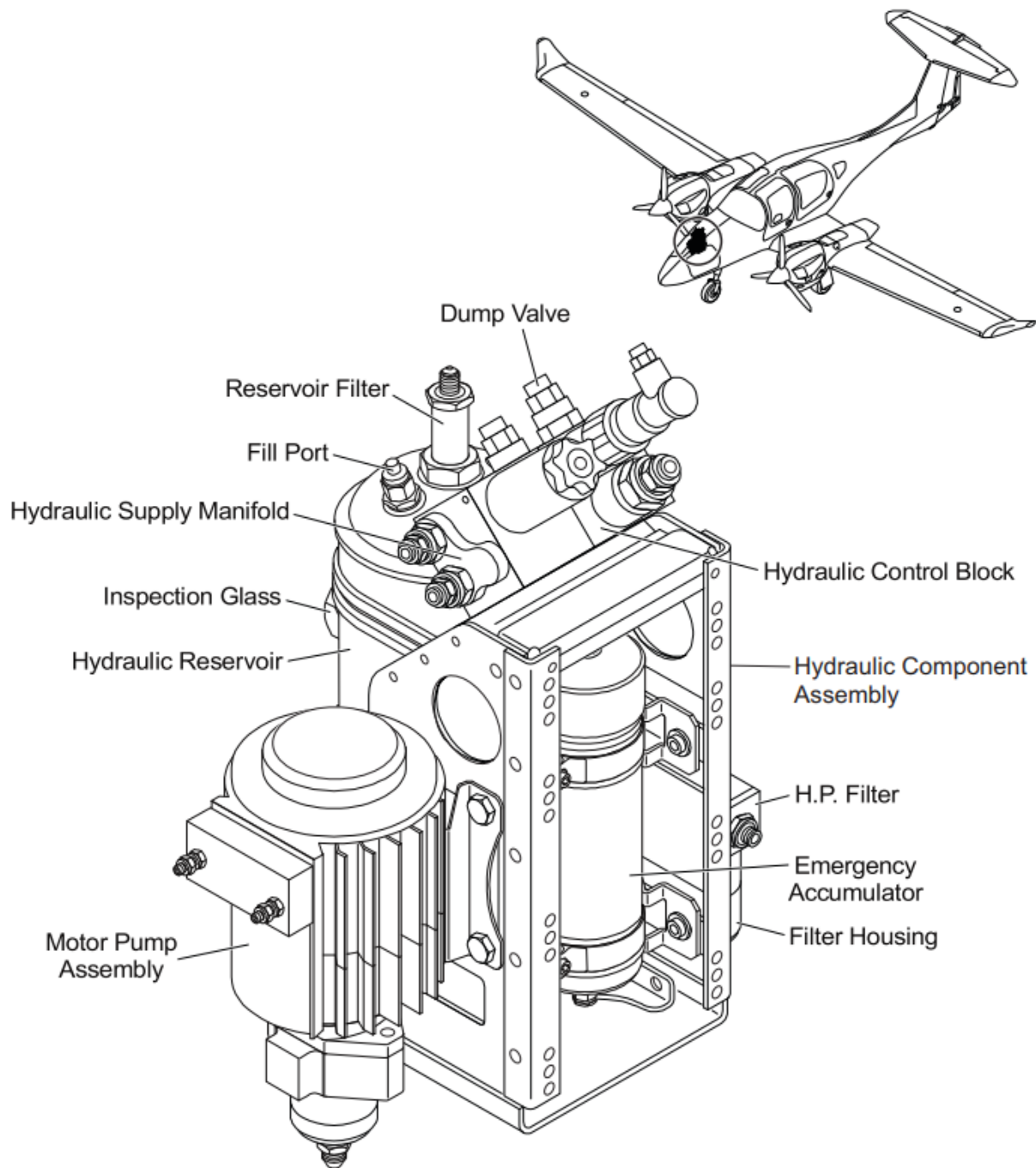


Figure 5. DA-62 hydraulic supply and control assembly. (Courtesy of Diamond Aircraft)

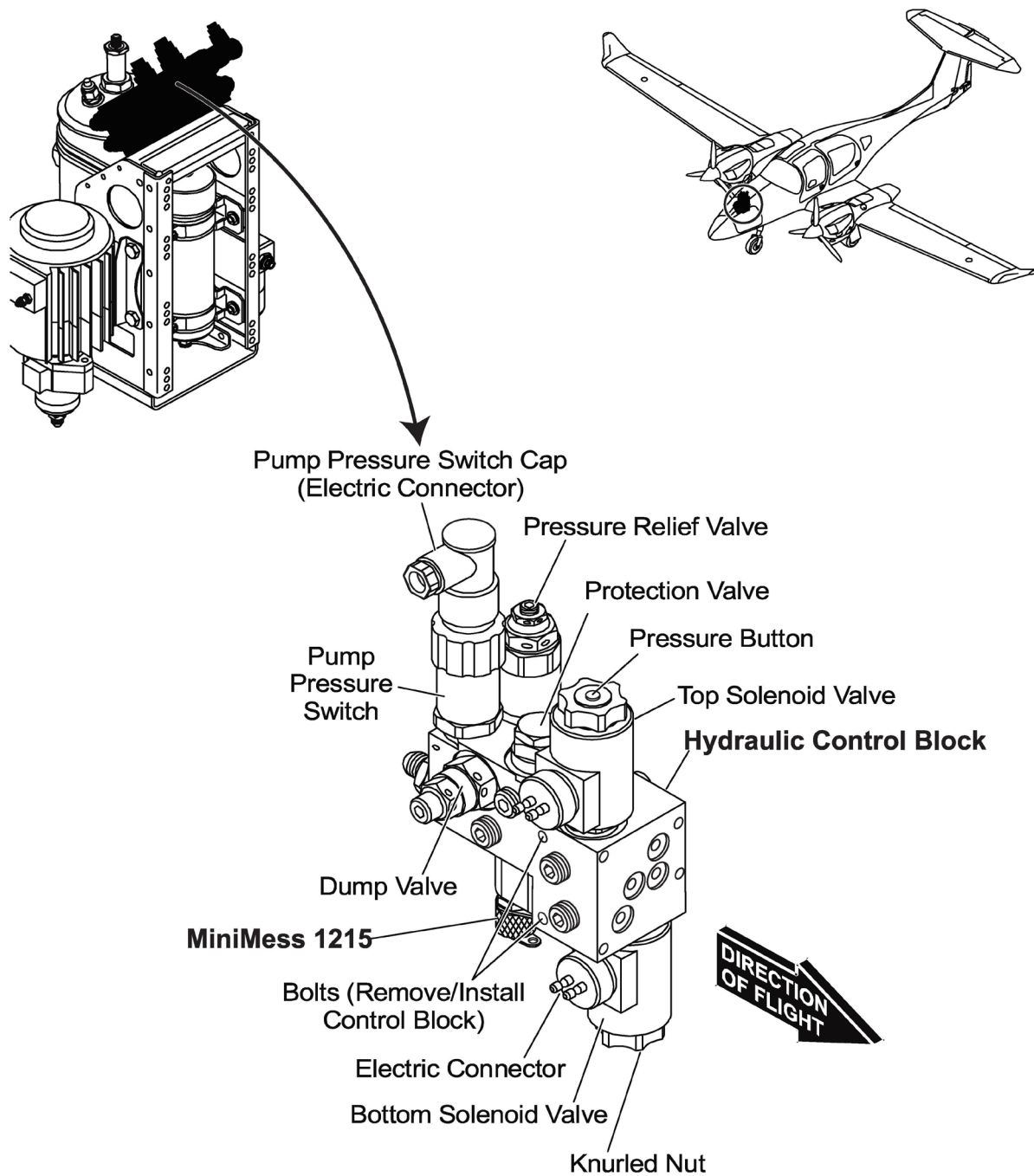


Figure 6. DA-62 hydraulic control block. (Courtesy of Diamond Aircraft)

E. DETAILS OF THE INVESTIGATION

1.0 Post Accident Findings

Immediately after the accident, an examination of the airplane, conducted by FAA personnel and Diamond Aircraft representatives, revealed incorrect wiring installation, and blown inline fuses for the backup ECU batteries for both engines. The ECU back-up batteries were connected in parallel versus in series. The main battery capacitance was tested and found to be low, near 70%. The Garmin and engine ECU data was downloaded. The data is documented in Electronic Devices - Specialist's Factual Report. The airplane was retained for further examination.

2.0 Aircraft Maintenance Records Review

A review of the aircraft maintenance records was completed. The relevant maintenance items are listed in Table 1. At the time of the accident, the airframe total time was 631.4 hours, and the last annual inspection was completed on 24 June 2022.

Table 1. Relevant aircraft maintenance records.

Description	Date	Aircraft Time	Next Due
ECU Back-up Batteries (Annual replacement)	7 May 2021	N/A	May 2022
Main battery capacitance check ²	24 June 2022	577.2	1577.2 / June 2023
ECU Back-up Batteries (Annual replacement)	24 June 2022	577.2	June 2023
Main battery replaced with part number (PN) RG24-15 serial number (SN) 40976083	21 September 2022	615.5	N/A

3.0 Aircraft Inspection and Testing

The aircraft examination was completed at the Dallas Executive Airport (RBD), Dallas, Texas on 25-26 January 2023. The examination consisted of measuring voltages of the aircraft batteries, visually examining the aircraft wiring and connections, completing continuity checks, installing the wings, and running the engines. While running the engines, the electrical load was varied to attempt to duplicate the accident flight loss of electrical power.

3.1 Visual Examination

The aircraft was examined. The aircraft was in a hangar at Dallas Executive Airport (RBD). The left and right wings were on a trailer in the hangar near the aircraft. The aircraft had damage to both propellers. There were several impact marks on the aircraft from impact with the cables along the road. Pictures of the impact marks were taken.

² This capacitance check was completed on the battery that was removed on 21 September 2022.

3.2 Battery Voltage Measurement

The voltages of all the batteries were checked and are listed in Table 2.

Table 2. Battery voltages.

Battery	Part Number	Serial Number	Voltage (VDC)
Main Battery:	RG24-15	40976083	25.5
LH ECU Back-up Battery 1:	NP7-12	N/A	12.6
LH ECU Back-up Battery 2:	NP7-12	N/A	12.2
RH ECU Back-up Battery 1:	NP7-12	N/A	12.6
RH ECU Back-up Battery 2:	NP7-12	N/A	12.2

3.3 Electrical System Inspection

An inspection of the electrical system was completed. The ECU back-up batteries were connected in parallel versus in series and the inline fuses were blown for both engines. The wiring from the main battery to the buses was checked for loose connections, failed fuses, burn marks or other signs of electrical issues. The wire from the negative battery terminal to the aircraft ground point was able to be rotated with moderate hand pressure. There were no signs of arcing. No other electrical system anomalies were identified.

The electric wiring from the and alternators was inspected for signs of loose connections, failed fuses, burn marks or other signs of electrical issues. At both alternator relays, the wiring was incorrect. As wired, the alternator relays would NOT disconnect the alternator power from the main electrical system. The relays would cut power to the glow plugs for the respective engines. (Note that the glow plugs are only used during engine start.) In addition, the 80 Amp fuse was not between the alternator and the aircraft electrical distribution system (Figure 7).

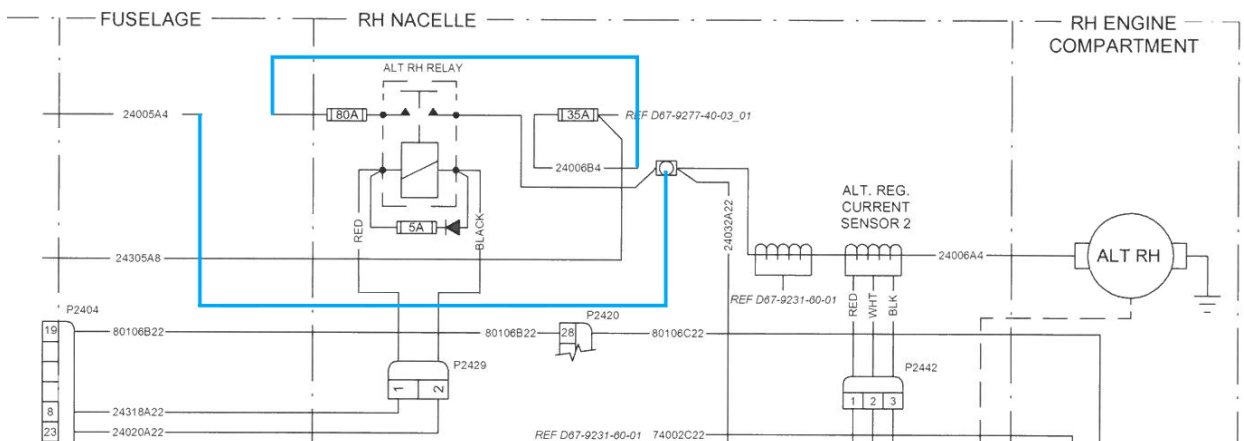


Figure 7. Drawing D67-9224-30-01_01 mark-up showing actual alternator relay wiring.

Instrument panel ground posts (3) were checked for security, looseness, and proper build-up. No anomalies were noted. Bonding checks were completed from the instrument panel, left alternator, and right alternator to the wire for the negative battery terminal.

Instrument panel ground stud to negative battery wire:	0.2 Ohms
LH alternator to negative battery wire:	0.1 Ohms
RH alternator to negative battery wire:	0.3 Ohms

The electric wiring from the third alternator to the air conditioning system was checked. The third alternator is optional and only powers the optional air conditioning system. The wiring was inspected for signs of loose connections, failed fuses, burn marks or other signs of electrical issues. No anomalies were identified.

3.4 Engine Runs with Main Battery Partially Discharged and ECU Back-up Batteries Disconnected

The wings were installed, and the fuel system connected. The left auxiliary fuel pump was used to transfer approximately 2 gallons of fuel from the left auxiliary fuel tank to the left main (wing) tank. The left engine was started. The aircraft voltage was 27.3 Volts (V). The left alternator switch was cycled ON/OFF and there was no change to the electrical system or engine operation. The right engine was started. The aircraft voltage was 27.3 V. The right alternator switch was cycled ON/OFF and there was no change to the electrical system or engine operation.

The wires on the diode blocks (left and right ECU buses) were wiggled. There was no impact to the electrical system or engine operation. The avionics master was selected OFF. The left and right alternator switches were selected OFF. The wires on the diode blocks were wiggled. There was no impact to the electrical system or engine operation. The left and right alternator switches were selected ON. The left engine was shutdown with the engine master switch. The right alternator switch was selected OFF. There was no impact to the electrical system or engine operation.

The left engine was restarted. The avionics master was selected ON. The CBs were verified to be pushed in except for the gear CB. (Note the "TWX"³ CB was out since the storm scope was removed. This CB was out for all on aircraft testing.) The left auxiliary fuel pump was selected OFF because the left auxiliary fuel tank was empty. The electrical load was increased by selecting the landing/taxi lights ON, left and right fuel pumps ON. The gear CB was pushed in (resulting in the hydraulic pump running). There was no change to the electrical system or engine operation except increased current draw. The hydraulic pressure was depleted, and the gear CB was pulled out. The communication system was keyed simultaneously with the

³ TWX is the transmitter for the weather radar.

gear CB reset (resulting in the hydraulic pump running). There was no change to the electrical system or engine operation except increased current draw.

The engine RPM was increased to speed-up the warming of the engine coolant in order to complete an ECU pre-flight test. (Reference Austro Engine Operation Manual E4P Document E4.01.02, section 4.1.4 Coolant temperature of >60C is required.) The left engine and right engine ECU tests were completed with no anomalies. The electrical master was selected OFF. There was no change to the electrical system or engine operation. (Normally the alternator power would have been disconnected from the corresponding main bus.) The alternator switches were selected ON, the hydraulic pressure was depleted, and the gear CB was pulled. Pitot heat was selected ON to increase electrical load. The wires at the diode blocks were wiggled. There was no change to the electrical system or engine operation.

The battery CBs were pulled. There was no change to the electrical system or engine operation. The electrical master was selected ON. The battery CBs were cycled. There was no change to the electrical system or engine operation. The engines were shutoff per normal procedure and the aircraft was placed in the hangar. After the testing, the main battery was at 21.7 V.

3.5 Engine Runs with Fully Charged Main Battery and ECU Back-up Batteries Disconnected

The main battery was removed and charged overnight. The battery was re-installed. The left and right engines were started. The CBs except gear were pushed in. After engine start, the electrical current on the display was "--" for a few seconds. The air conditioning was selected ON but did not engage or function. The lights, fuel pump and pitot heat were selected ON. The gear CB was pushed in as the mic was keyed. There was no change to the electrical system or engine operation.

The left and right alternator switches were selected OFF. The left and right alternator CBs were pulled. The left ECU bus and right ECU bus CBs were pulled. The electrical master was selected OFF. The engines stopped.

The electrical master was selected ON. The left and right alternator CBs were pushed in. The left and right alternator switches were selected ON. The left and right engines were restarted. The left and right alternator switches were selected OFF. The left and right alternator CBs were pulled. The electrical master was selected OFF. The engines stopped.

3.6 Engine Runs with Fully Charged Main Battery and ECU Back-up Batteries Connected Properly

The ECU back-up batteries were connected properly with new fuses. The left and right engines were started. The CBs except gear CB were verified to be pushed in. Then the gear CB was pushed in. The left and right alternator switches were selected OFF. The left and right alternator CBs were pulled. The electrical master was selected OFF. The engines remained running but the displays shutdown. (This was the expected outcome.)

The electrical master was selected ON. The left and right alternator CBs were pushed in. The left and right alternator switches were selected ON. The left and right alternator switches were selected OFF. The left and right alternator CBs were pulled. The left ECU bus and right ECU bus CBs were pulled. The electrical master was selected OFF. The engines remained running but the displays shutdown. (This was the expected outcome.)

The electrical master was selected ON. The left and right alternator CBs were pushed in. The left and right alternator switches were selected ON. The engines were shutdown by selecting engine master switches OFF.

3.7 Engine Runs with Partially Depleted Main Battery and ECU Back-up Batteries Misconnected as per the Accident Flight

The ECU back-up batteries were connected in parallel which was the same way they were connected during the accident flight. The main battery voltage was <23.3 V at the start of these checks. The left and right engines were started. The CBs except gear CB were verified to be pushed in. Then the gear CB was pushed in. The peak electrical load was approximately 71 amps.

The left and right alternator switches were selected OFF. The left and right alternator CBs were pulled. The ECU bus CBs were pulled. The electrical master was selected OFF. The engines stopped. The ECU back-up batteries and fuses were warm. The fuses were still intact.

With the engines not operating, the left ECU back-up battery fuse was installed. The electrical master was selected ON. The left engine master was selected ON. After approximately 5 seconds, the left ECU batteries were warm.

3.8 Parts Retained for Further Examination

Table 3 lists the parts that were retained by the NTSB for further examination.

Table 3. Parts retained for further testing.

Component	Part number	Serial number
Main Battery:	RG24-15	40976083
LH ECU:	E4PC-92-000-000	2024
LH Alternator: Mahle	AAL5106	11.204.500 17-192
	E4A-91-400-000	AB1# 01217
LH Voltage Regulator:	E4A-91-200-000-011	1448 Date of Manufacture: 11/2017 Charge #: 1927667
RH ECU:	E4PC-92-000-000	2025
RH Alternator: Mahle	AAL5106	11.204.500 17-192
	E4A-91-400-000	AB1# 01211
RH Voltage Regulator:	E4A-91-200-000-011	1411 Date of Manufacture: 11/2017 Charge #: 1927667
Hydraulic Power Pack	D67-9029-13-00	0074
Battery Cables	24000A2 and 24001A2N	N/A

4.0 Battery Testing

The battery was shipped to Concorde Battery Corporation and testing on 20-22 April 2023.

4.1 Battery History

Concorde Battery was able to retrieve the original acceptance testing records for the battery.

- Monobloc Lot # = 080818-012
- Final Assembly Lot # = 082918-003
- Finished Weight = 28.13 pounds
- Open Circuit Voltage = 26.44 V
- C1 Capacity to 20V end point voltage (EPV) = 13.3 Ah
- Constant 14V Discharge = 584A @ 15 seconds
- Date released to warehouse = 9/14/2018

The battery was sold and shipped to Airparts Supply Co. (UK) on 31 October 2018. The Battery was installed on DA-62 Reg. No. A7-KAA on 20 December 2019. The battery was returned to Concorde, a capacity check was performed on 21 July 2021 and the result was 90.9% capacitance. The battery was installed on DA-62 Reg. No. N84LT on 21 September 2022. The maximum DC load of equipment installed on DA-62 Reg. No. N84LT is 53.6 Amps based on the Electrical Load Analysis (ELA) document provided by Diamond Aircraft.

4.2 Physical Examination

The battery part number and serial number were confirmed to be RG24-15 and 40976083.

The battery was weighed and measured. The weight was 28.025 pounds. The Length (Front to back) was 7.33 inches., the width (side to side) was 7.38 inches, and the height (to cosmetic cover) was 5.86 inches.

There were minor scuff marks on the rear edge of the cosmetic cover. The front label had areas where the clear laminate was peeling and some areas where the printed text was scuffed and illegible. No damage or discoloring of the battery terminals was observed. There was no sign of electrolyte leakage. There was no sign of cells open to atmosphere. Photos were taken of all sides of the battery (Figure 8).



Figure 8. Photos of main battery. (Courtesy of Concorde Battery)

4.3 Electrical Examination

Using a Fluke digital multimeter, the battery open circuit voltage (OCV) was measured to be 25.39 V. Using an HP 4338A milliohm meter, the internal resistance (IR) of the battery was measured at 17.6 milliohms.

The battery was subjected to the conditioning charge procedure of its component maintenance manual (CMM). The battery was discharged at a rate of 13.6 Amps to an EPV of 20 V. The battery delivered 5.79 Ah of capacity (42.6% of rated capacity). The battery was charged at a constant current rate of 1.36 Amps for 16 hours. The battery accepted 21.74 Ah of capacity. Battery maximum voltage on charge was 34.31 V. Battery maximum temperature on charge was 55°C. After charging, the battery rested for 8 hours to cool down and its temperature was 29°C after 8 hours of rest.

A battery capacity test was completed. The battery was discharged at a rate of 13.6 Amps to an EPV of 20 V. The battery delivered 11.04 Ah (81.2% of rated capacity). The minimum requirement for passing is 85%, so it did not pass the capacity check. Concorde's CMM allows up to 3 conditioning cycles before declaring it has failed capacitance test. No additional cycles were completed.

The battery was charged at 28.25V for 6 hours to bring it back to 100% state of charge. The battery accepted 13.03 Ah of capacity.

A high rate discharge (constant voltage discharge) was completed. The battery was discharged at a constant voltage of 14 V for 30 seconds. The voltage and current were recorded at 0.1 second intervals for the first second of testing and 1 second intervals for the remainder of testing. The battery delivered 599 Amps at 0.3 seconds and 296 Amps at 15 seconds. Figure 9 shows the data from the high rate discharge test. There were no pass/fail criteria for the high rate discharge test. These results were considered normal for a battery that is over 4 years old.

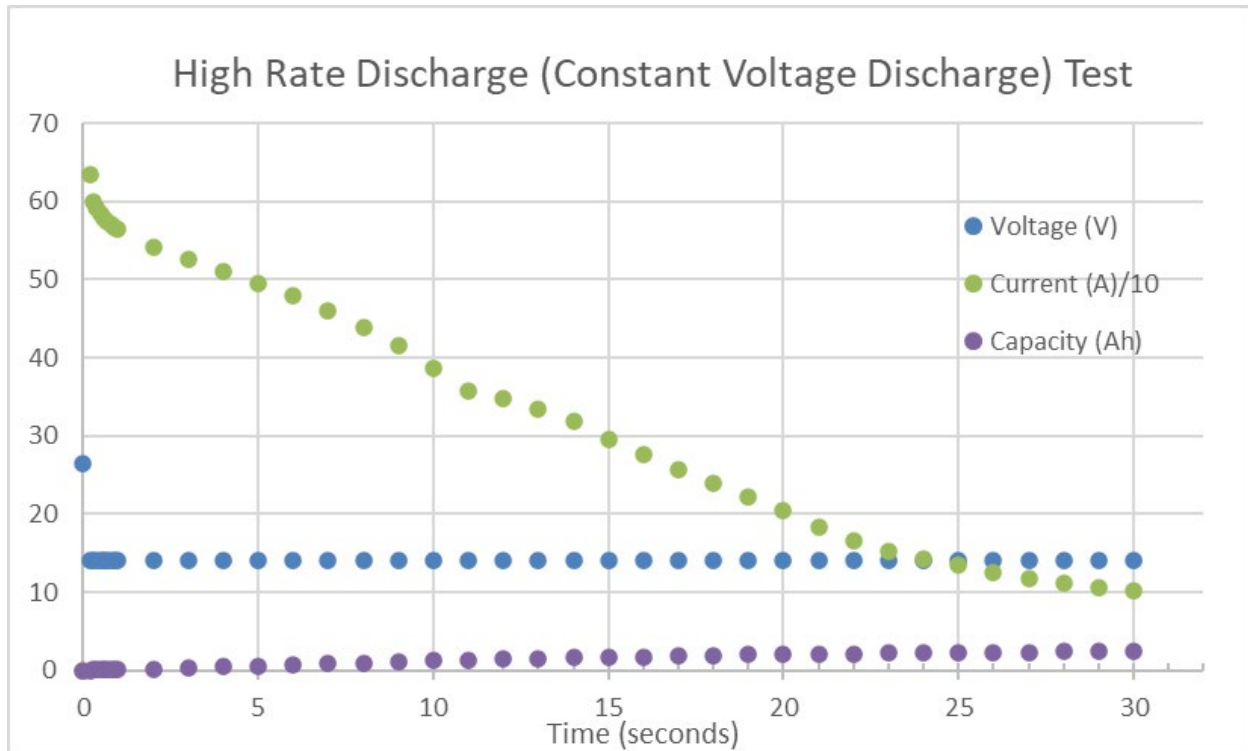


Figure 9. Plot of high rate discharge test data.

5.0 Voltage Regulators and Alternators Examination

The voltage regulators and alternators were shipped to Austro Engines and tested on 7 April 2023.

5.1 Voltage Regulators

LH voltage regulator part number E4A-91-200-000-011 serial number 1448 and RH voltage regulator part number 4A-91-200-000-011 serial number 1411 were tested per Test Plan P004.06.06. Both regulators passed all testing without any under/overshoots observed. Figure 10 shows the test set-up for the voltage regulators.

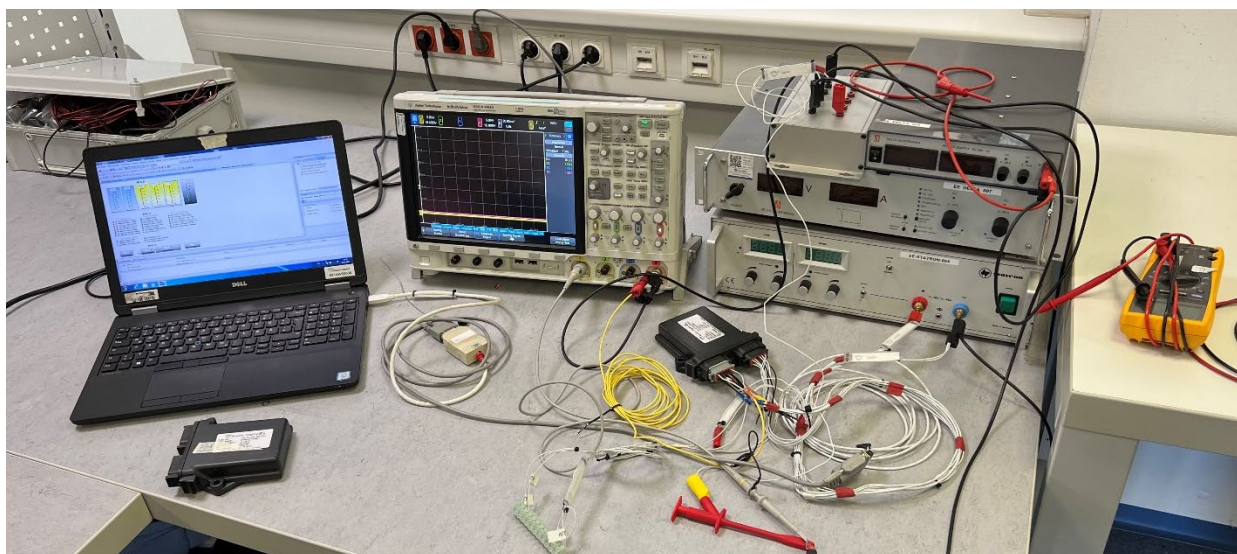


Figure 10. Photo of the voltage regulator test set-up. (Courtesy of Austro Engines)

5.2 Alternator Testing

LH alternator part number E4A-91-400-000 serial number 01217 and RH alternator part number E4A-91-400-000 serial number 01211 were tested per Test Plan P004.06.06. Both alternators passed all testing. Table 4 show the results of the diode and field resistance checks.

Table 4. Alternator diode and field resistance checks.

Measurement	Acceptable value	LH Alternator S/N 1217	RH Alternator S/N 1211
Field resistance	2.5 – 9 Ohms	7.3	8.6
Positive terminal of DMM to B+ and negative terminal of DMM to alternator housing	Open load	Open load	Open load
Negative terminal of DMM to B+ and positive terminal of DMM to alternator housing	0.8 – 1.1V	1.04 V	1.05V

6.0 ECU Examination

ECUs part number E4PC-92-000-000 serial numbers 2024 and 2025 were examined by Austro Engines to see if additional data from the accident flight could be recovered. No additional data was obtained.

7.0 Hydraulic Power Pack Examination

Hydraulic Power Pack part number D67-9029-13-00 serial number 0074 was tested at Austro Engines on 29 June 2023. During the receiving inspection, it was observed that the electrical connector to the pump pressure switch was damaged (Figure 11). But the unit was still able to be tested.

The hydraulic power pack was connected to aircraft serial number 62.243 (Figure 12). The hydraulic system was bled. A one Ohm shunt resistor was installed inline with the electrical supply to measure current.

A voltage peak of 2.0 V was measured across the shunt-resistor the moment the hydraulic pump was turned on (Figure 13). This voltage corresponds to a current peak of 200 Amps. During the remainder of pump operation, a voltage drop of 0.25 V was measured across the shunt-resistor. This voltage corresponds to an average current of approximately 25 Amps (Figure 14).

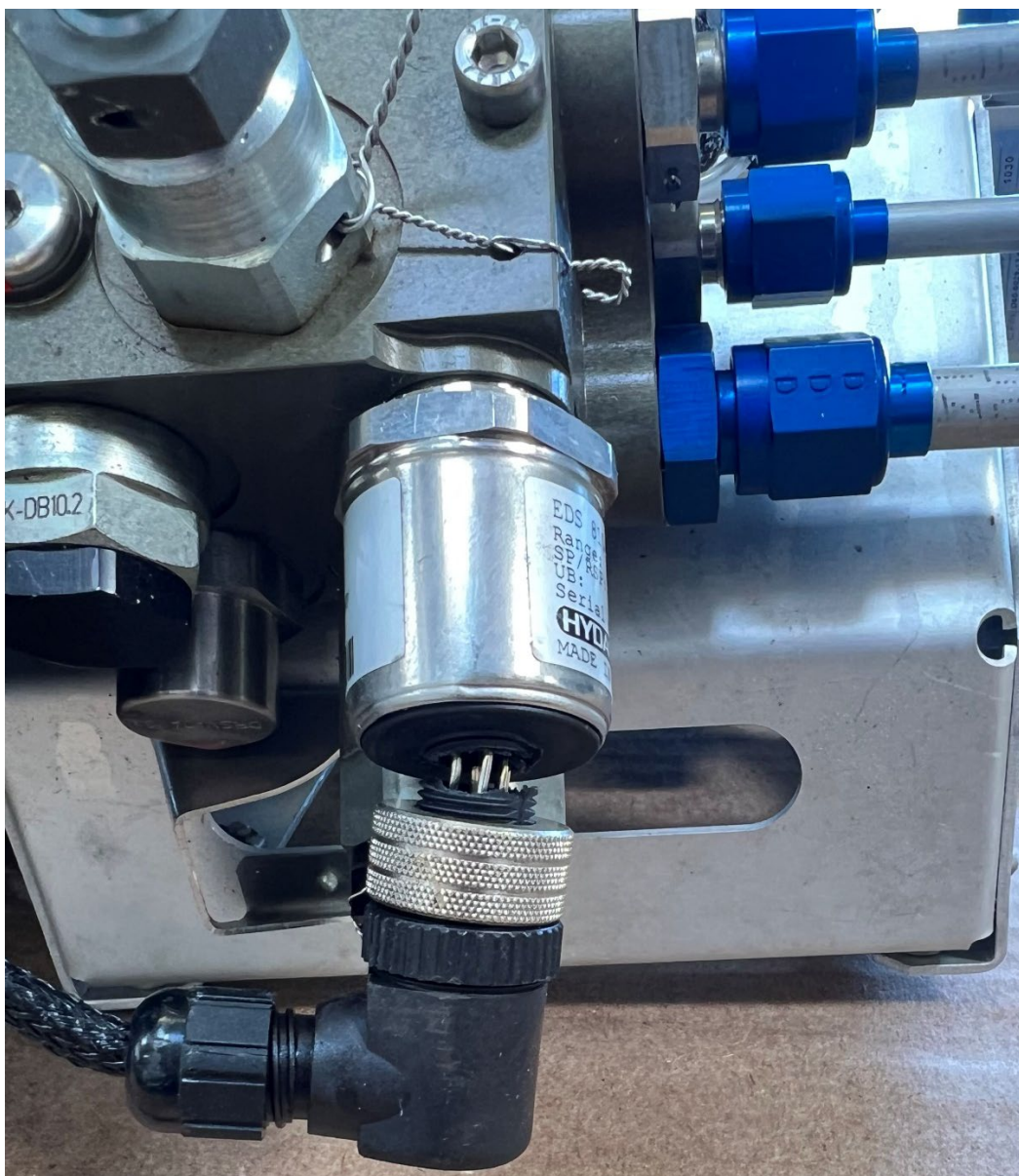


Figure 11. Photo of the damage to the pump pressure switch electrical connector. (Courtesy of Austro Engines)

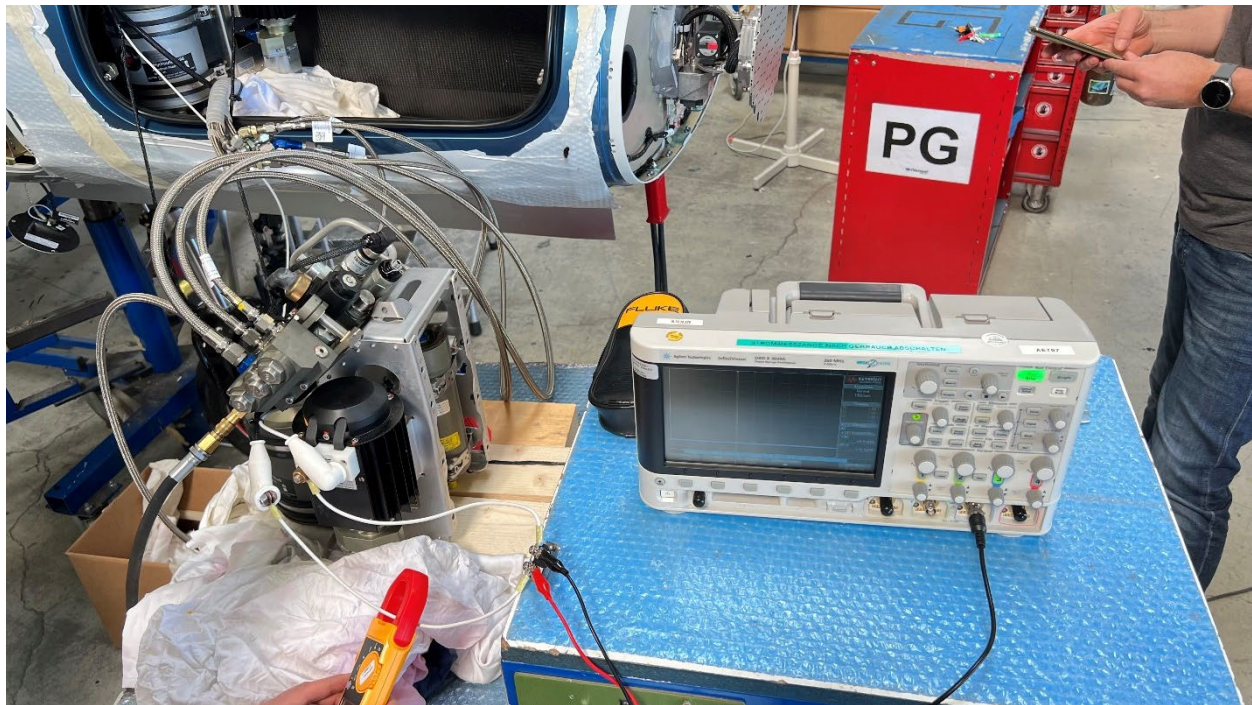


Figure 12. Photo of the hydraulic power pack test set-up. (Courtesy of Austro Engines)

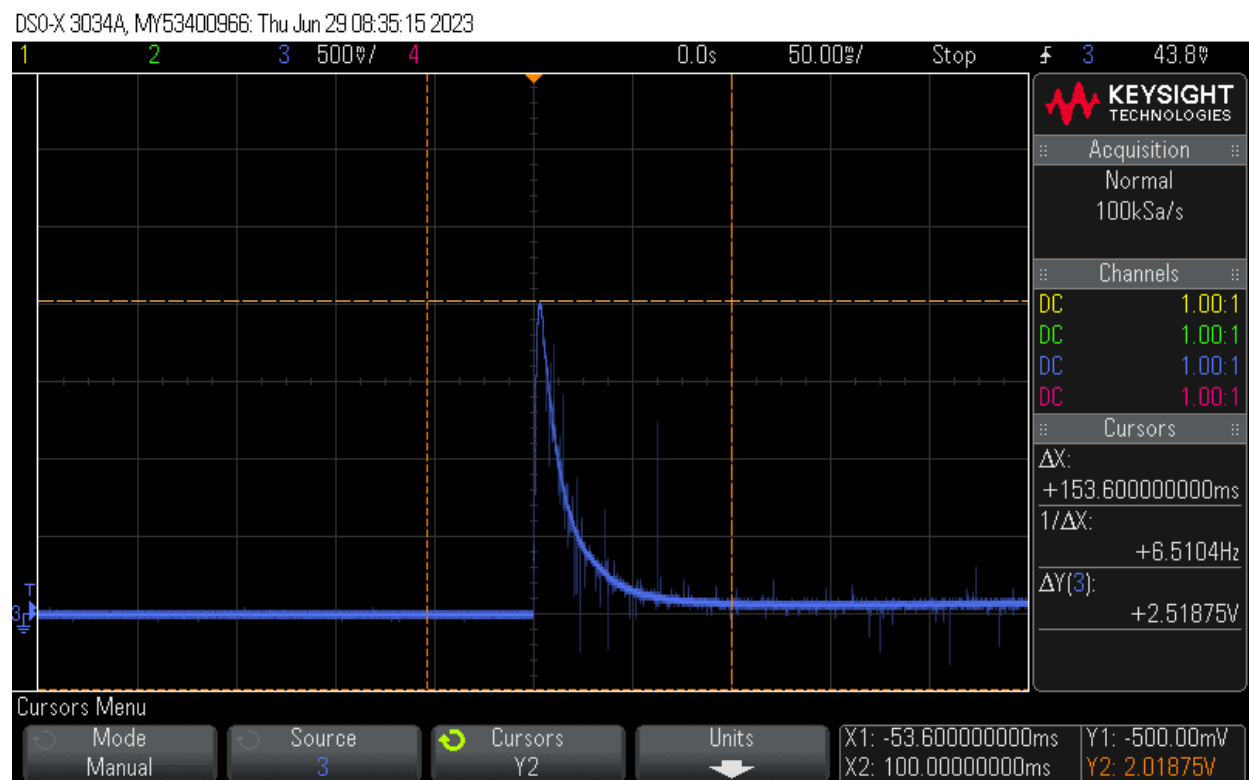


Figure 13. Photo of the hydraulic power pack motor starting current. (Courtesy of Austro Engines)

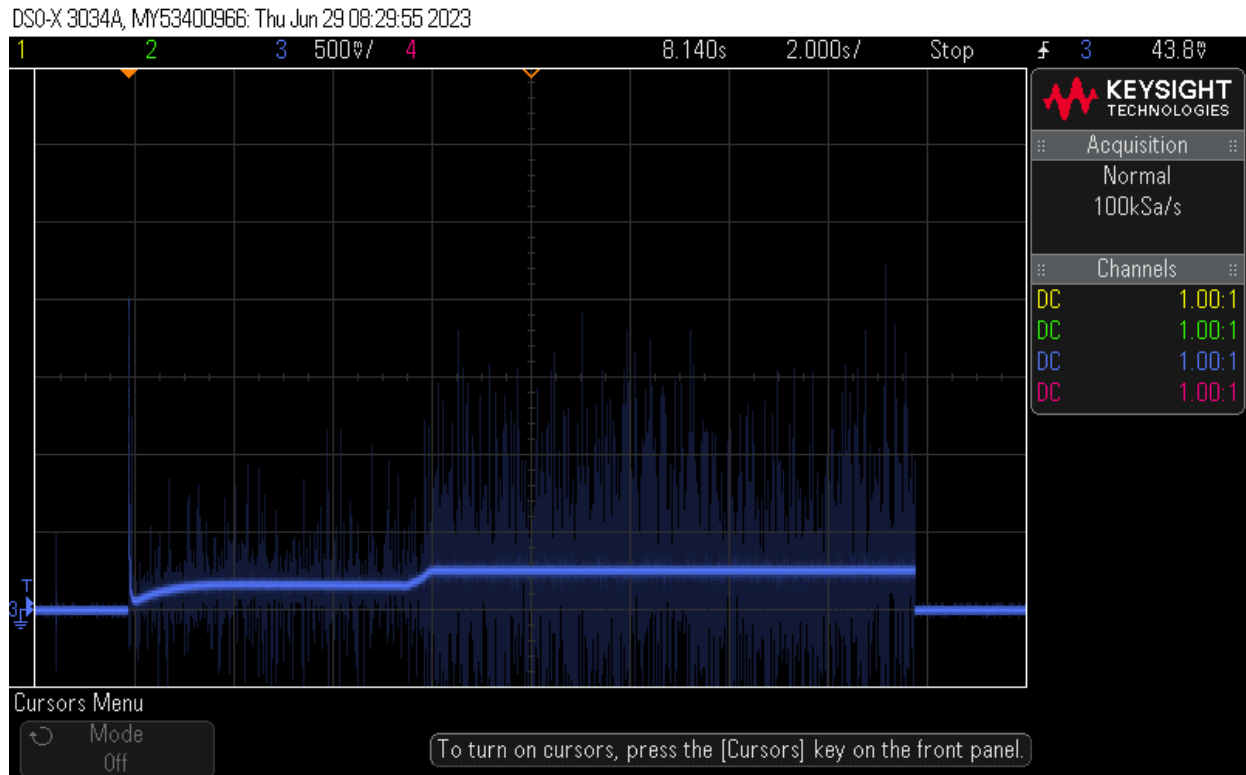


Figure 14. Photo of the hydraulic power pack operating current. (Courtesy of Austro Engines)

7.1 Exemplar Power Pack Results

The hydraulic power pack from aircraft serial number 62.243 was used as an exemplar unit. The testing was repeated on this unit. A voltage peak of 2.4 V was measured across the shunt-resistor the moment the hydraulic pump was turned on (Figure 15). This voltage corresponds to a current peak of 240 Amps. A voltage drop of 0.25 V across the shunt-resistor corresponds to an average current of approximately 25 Amps (Figure 16).

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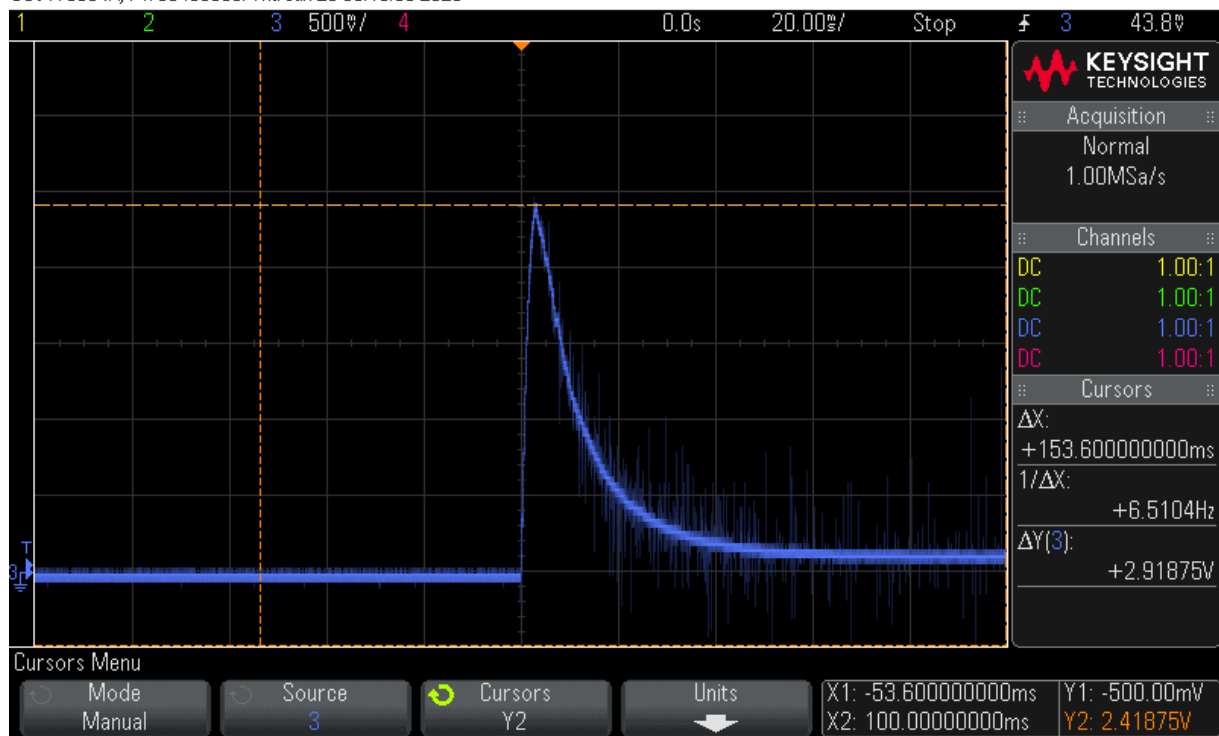


Figure 15. Photo of the exemplar hydraulic power pack motor starting current. (Courtesy of Austro Engines)

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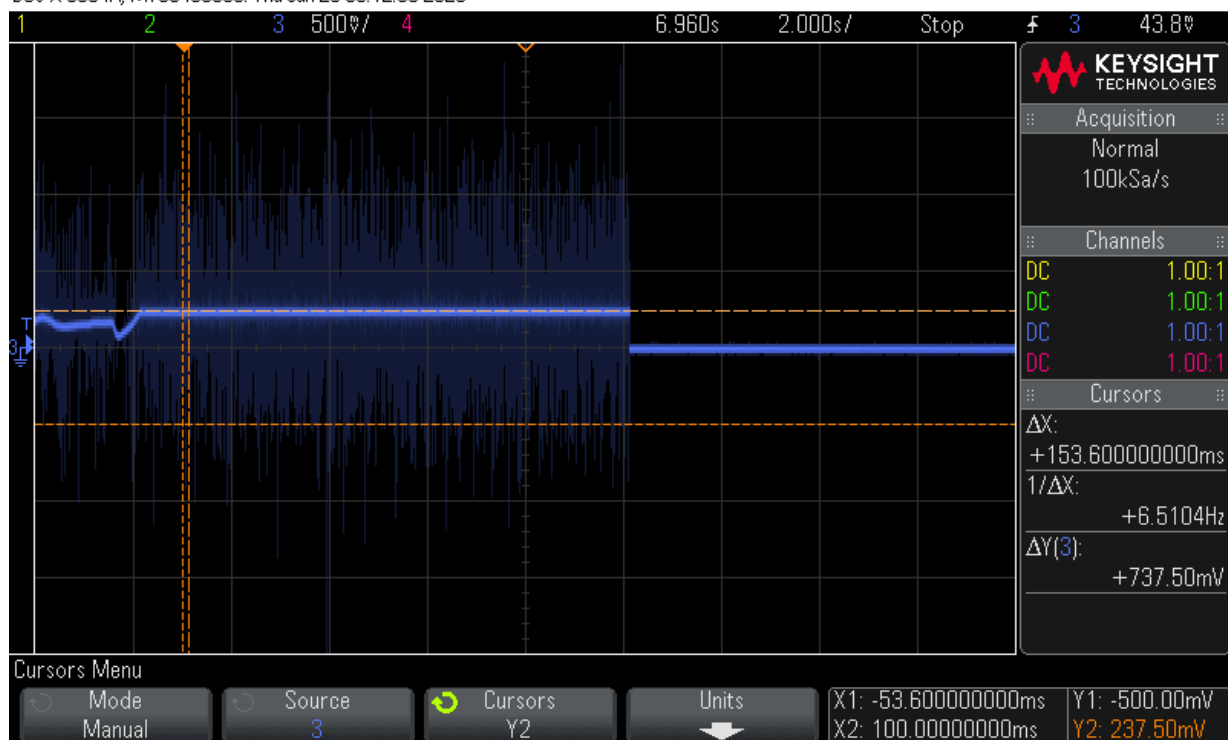


Figure 16. Photo of the exemplar hydraulic power pack operating current. (Courtesy of Austro Engines)

8.0 Battery Cable Examination

Battery cables PN 24000A2 and 24001A2N were examined at the NTSB materials laboratory. Battery cables PN 24000A2 and 24001A2N were 30 inch-long aviation battery cables with lugged ends. No arcing features were observed on the four battery cable lug surfaces including the contact surfaces. All surfaces were examined under a 5X to 50X stereo-zoom microscope.

F. AIRCRAFT MAINTENANCE MANUAL (AMM) REVIEW

A review of the AMM was completed. See Attachment 1 for an extract of Section 05-10-00 component time limits. A battery capacitance check is required every year $\pm$ 30 days or 1000 $\pm$ 100 hours.

See Attachment 2 for an extract of the ECU back-up battery removal and installation instructions from the AMM. The AMM ECU back-up battery installation task does not have a step to ensure the ECU back-up batteries are connected correctly and functioning properly. The installation task requests an engine ground run to ensure the electrical system operates correctly. Unless the main electrical system is failed, the ECU back-up batteries will not be used.

After this accident, Diamond Aircraft published Service Information Letter No. SI62-034 - Inspection of ECU Backup Batteries Wiring Installation on all DA-62 aircraft (See Attachment 3). This verified the ECU back-up batteries were connected correctly and the in-line fuse was intact.

G. LIST OF ATTACHMENTS

1. Attachment 1 Aircraft Maintenance Manual Section 05-10-00 Component Time Limits Extract
2. Attachment 2 Aircraft Maintenance Manual Section 24-30 Battery Systems – Extract of ECU Back-up Batteries Information and Procedures
3. Attachment 3 Service Information Letter NO. SI62-034 - Inspection of ECU Backup Batteries Wiring Installation on All DA-62 Aircraft

Submitted by:

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