NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Western Pacific Region

Y-SAS SYSTEM EXAMINATION

WPR22FA101

A. ACCIDENT

Location:	Newport Beach, CA
Date:	February 19, 2022
Aircraft:	MD Helicopters/500N/N521HB
NTSB IIC:	Eliott Simpson

B. EXAMINATION PARTICIPANTS:

Eliott Simpson
Senior Aviation Accident Investigator
National Transportation Safety Board

Joan Gregoire
Aviation Safety Investigator
MD Helicopters

Jeff Goodspeed
Huntington Beach Police Department
Air Support

C. SUMMARY

Examination of the Y-SAS components was conducted at the facilities of Astronautics Corporation of America, in Oak Creek, Wisconsin on May 4, 2022. All components exhibited evidence of water infiltration and corrosion (figure 1).

D. DETAILS OF THE INVESTIGATION

1.0 Examination

1.1 Rate Gyro

Part No:17595-5
Serial No: 008983-1128

Astronautics records indicated that the unit was manufactured on February 18, 1997, and had not been returned for overhaul.

The unit appeared externally undamaged, and its serial number was no longer visible. The serial number was tracked using internal records based on a code that had been engraved into the lid.

The lid was removed, and the unit internally examined. The printed circuit board (PCB) and all components were intact and appeared undamaged. There was evidence of water intrusion, demonstrated by white corrosion deposits around the bolt threads, bolt heads, and standoffs at the intersection with the case (figure 2). The PCB appeared covered in a conformal coating and did not exhibit evidence of corrosion (figure 2).

The unit was installed in a calibrated test stand and tested in accordance with the most current acceptance test procedures (ATP) 0778. The test involved installing the unit on a rotating table and checking the output voltage at various accelerations in each plane.

The results for acceleration sensitivity were about 463 mV in all directions. The nominal values should have been 0 +/- 30 mV.

A linearity, accuracy, sensitivity, and range test was performed in both directions at speeds varying from 5°/s to 20°/s. The results indicated a similar offset of 463 mV was present in all tests.

1.2 Yaw Damper Computer (“Control Box”)

Part No: 168240-1
Serial No: 008983-0112

Astronautics records indicated that the unit was manufactured on October 21, 1993 and had not been returned for overhaul.

The unit appeared externally undamaged and was coated in white corrosion-like deposits. The lid was removed, and the unit internally examined.

There was evidence of water intrusion, demonstrated by white and rust-colored corrosion deposits around multiple components on the PCB, wires, bolt threads, bolt heads, and standoffs (figure 3). Two diodes, located next to the DC to DC regulator, displayed evidence of corrosion that appeared to have penetrated inside of their cases.

Before commencing with an ATP test, the resistance of the power inputs, and output drives was checked, and there was no short-circuit.

The unit was installed in a calibrated test stand and tested in accordance with the most current ATP (07225C). The test involved installing the unit on a rotating table and checking the output voltage for various accelerations in each plane. The unit appeared to be non-functional because only three of the seven tests could be accomplished. The results were as follows:

Power On:
PASSED

DC-DC Converter Test:
Outputs = +14.98 vdc, and -14.96vdc. The nominal values were +/- 15 vdc +/- 0.5vdc.
PASSED

Yaw Damper Enable Test:

FAILED – ENA light would not turn on

Yaw Rate Monitor Gain:

Outputs = -1.501 vdc, and +1.506 vdc. The nominal values were between 1.35 and 1.65 (+/- vdc.
PASSED

Accelerometer Monitor Gain

Outputs = +1.473 vdc, and -1.401 vdc. The nominal values were between 1.07 and 1.67 (+/- vdc.
PASSED

Yaw Rate Washout

No movement observed – FAILED

Accelerometer Washout:

No signal observed - FAILED

1.3 Linear Actuator

Part No: 165490-5
Serial No: 008983-1025

Astronautics records indicated that the unit was manufactured before the year 2000, and that it had last returned for service in May 2020. The factory seals and paint were intact, indicating the unit had not been opened since service.

The exterior of the unit appeared undamaged, with white corrosion deposits at the various section of the case seals (figure 4) and at the heads of the case screws. During examination, water was observed to weep from one of the lower case screws. The output shaft exhibited an extension of 0.599 inches, the nominal, neutral, “zero” position value was 0.45 inches.

A preliminary functional check was performed utilizing a test bench; however, the unit emitted a “chattering” sound, and would not respond to control inputs.

The rod end bearing was in place and set to an appropriate torque, and was then removed, along with the grease seal and spline housing. The seal springs appeared to have been installed in the correct order, and the shaft, gear, and seal were still coated in grease and undamaged. The shaft was then unscrewed from the rotor and came out unhindered. The shaft was intact and straight, and its shims had been installed in the correct order.

Within the rotor housing, there was evidence of water intrusion and corrosion. The unit was then reassembled and checked on the test bench with the same results.

The entire unit was then dissembled, and corrosion was observed within the circuit board and motor housings, and the external case of the LVDT unit (figure 5). The motor’s rotor was removed, and green corrosion-like deposits were present on its outer surface (figure 6). The corresponding stator winding assembly was damp and similarly corroded (figure 7).

The LVDT shaft assembly was removed and appeared undamaged and coated in grease.

Examination of the circuit boards revealed that the L2 inductor exhibited a longitudinal crack and appeared to be emitting dark-brown deposits out of the crack, and at its base (figure 8). According to the circuit diagram, L2 is a 15 μH inductor, configured to supply +15 Vdc power to a 5v 7805 series regulator (VR1). The regulator in turn supplies 5 Vdc to the 8795 series microcontroller (U2).

The resistance across the inductor was measured at about 39 ohms, and the output side of the inductor was measured to be 600 Kohms to ground.

The yaw damper, “DC to DC regulator” test results (PASSED) indicated that the inductor was being supplied with the appropriate voltage.

2.0 Examination Figures

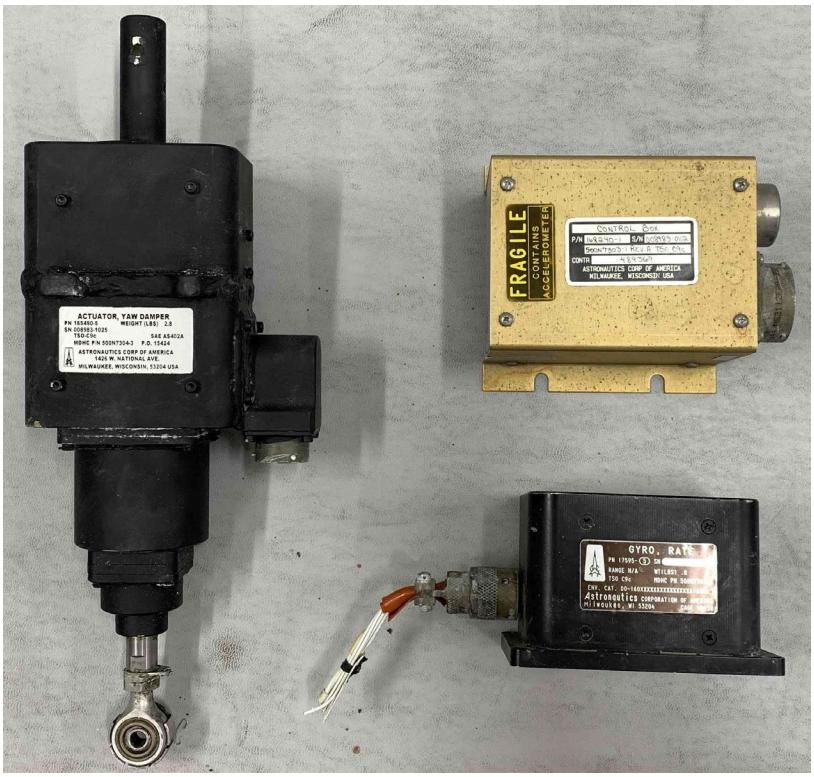

Figure 1 – Examined components

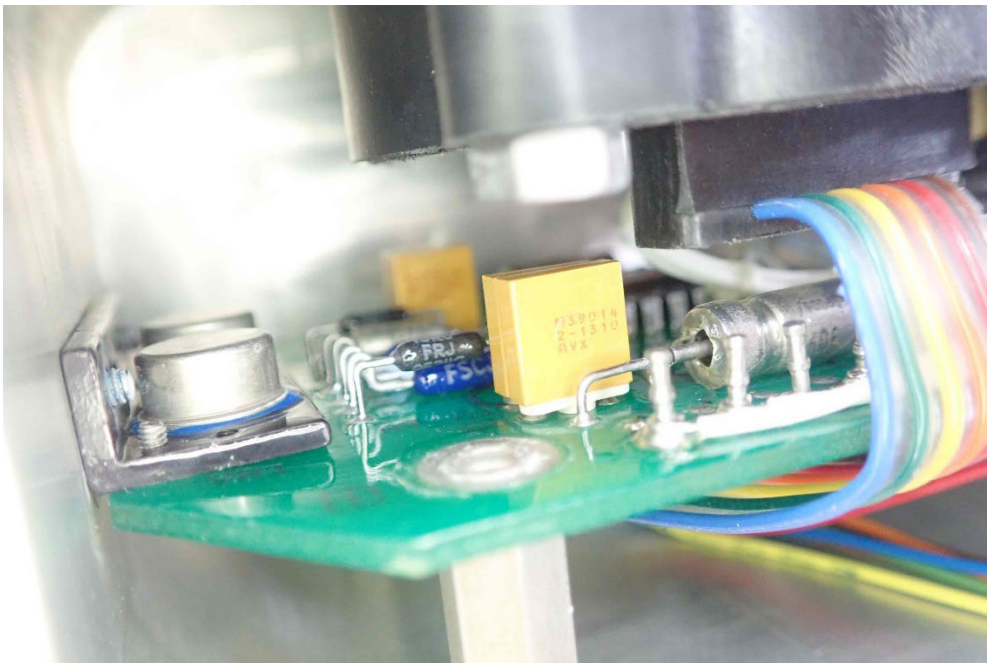

Figure 2 – Rate Gyro PCB

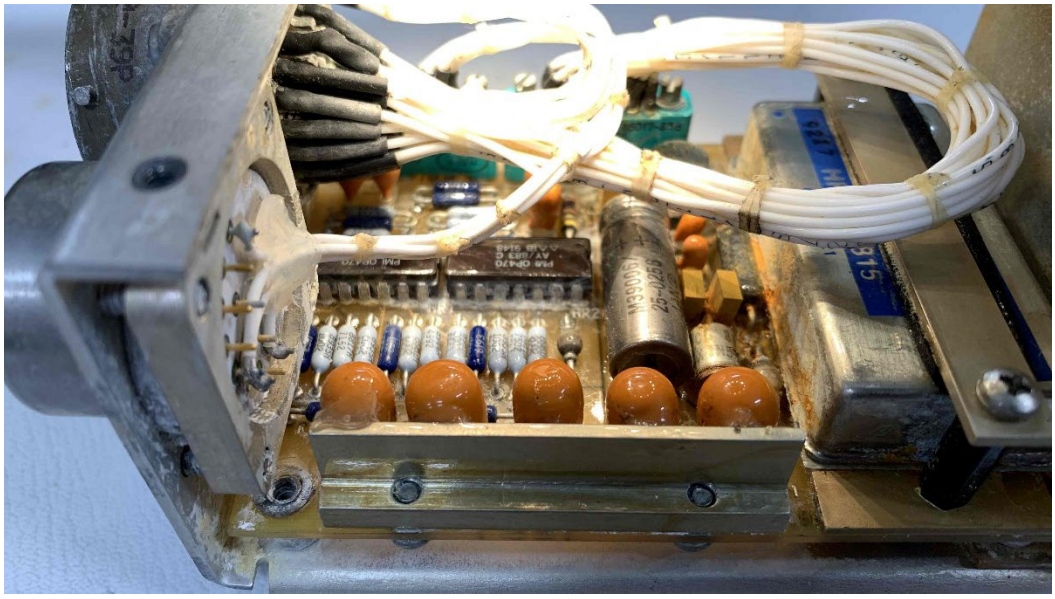

Figure 3 – Yaw Damper Controller

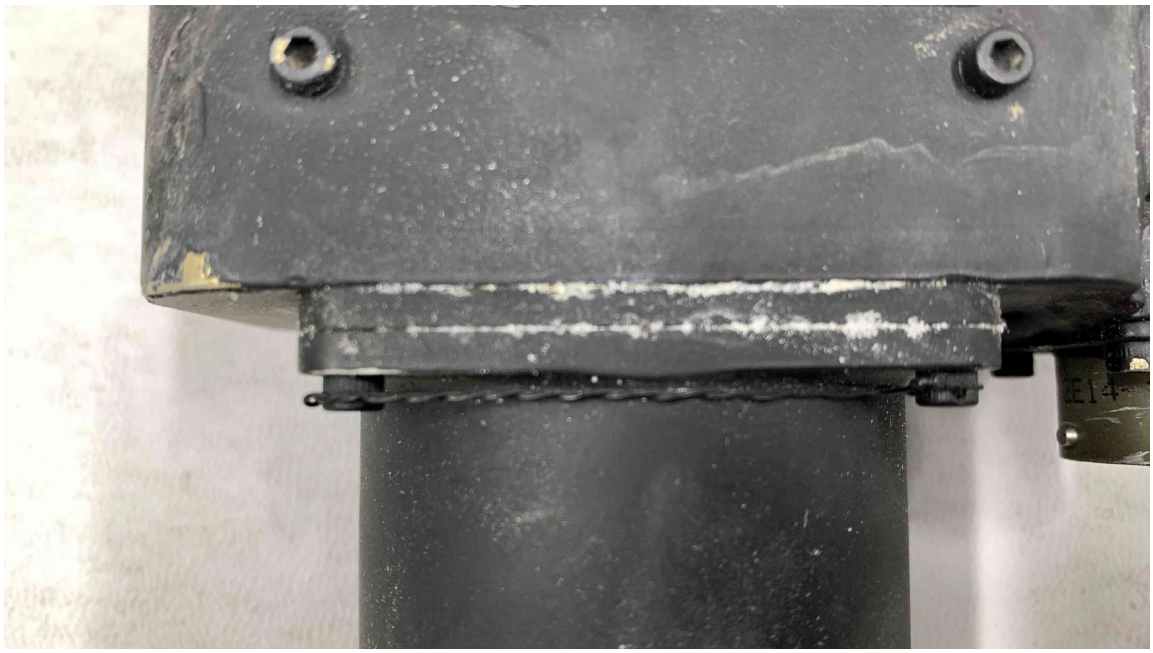

Figure 4 – Linear Actuator outer case

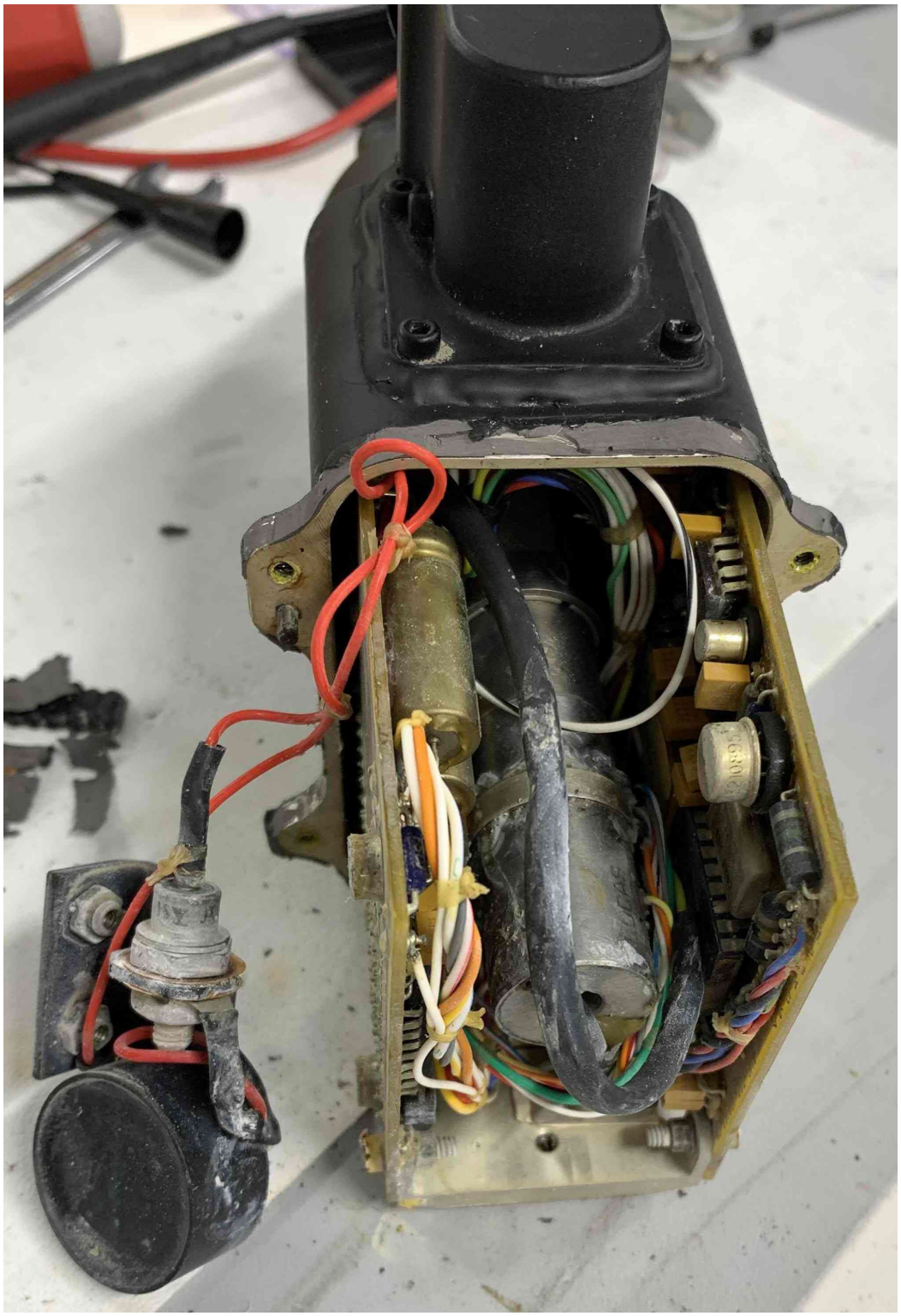

Figure 5 – Linear Actuator PCB and LVDT case

Figure 6 – Motor rotor

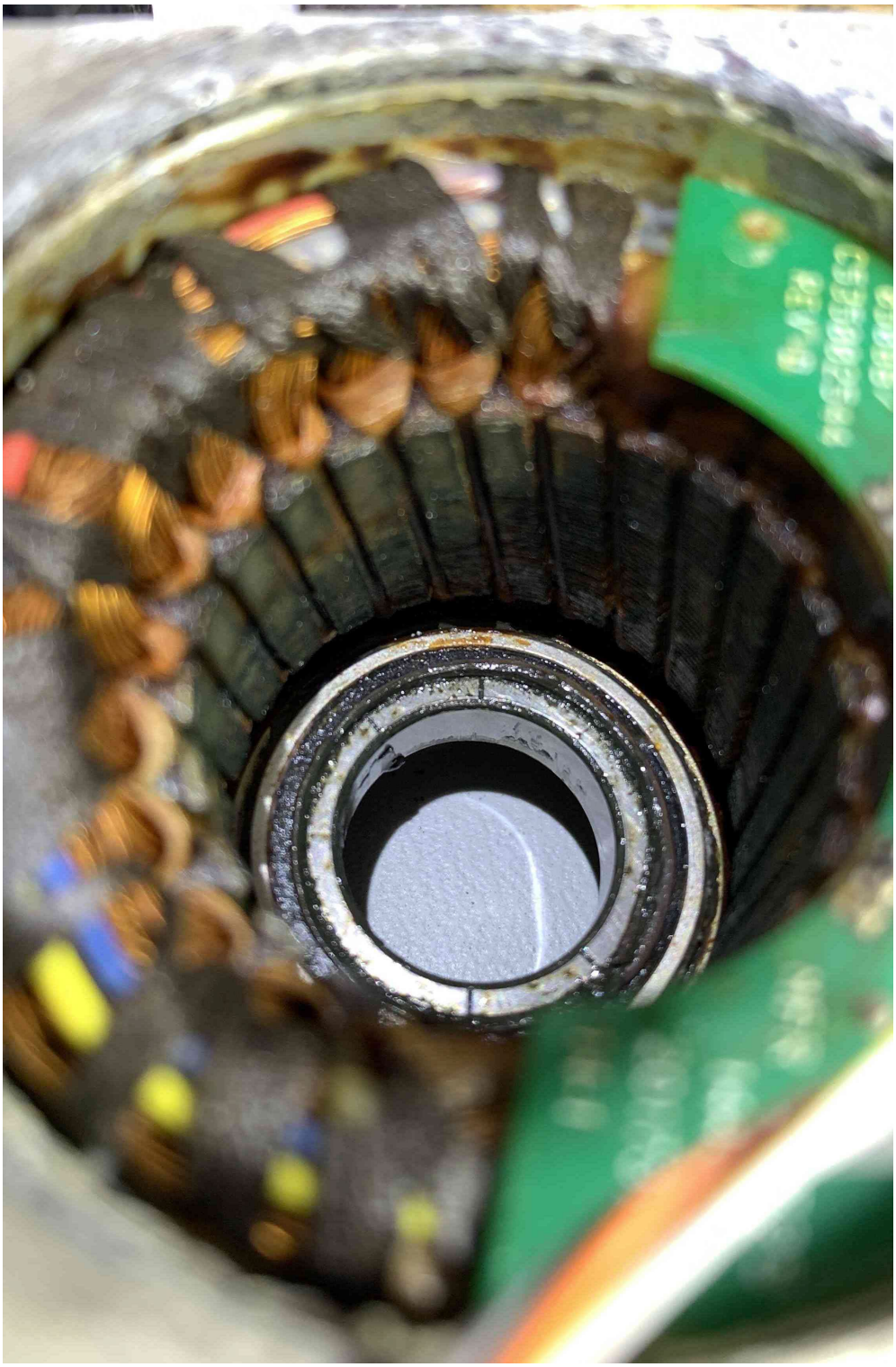

Figure 7 – Motor stator

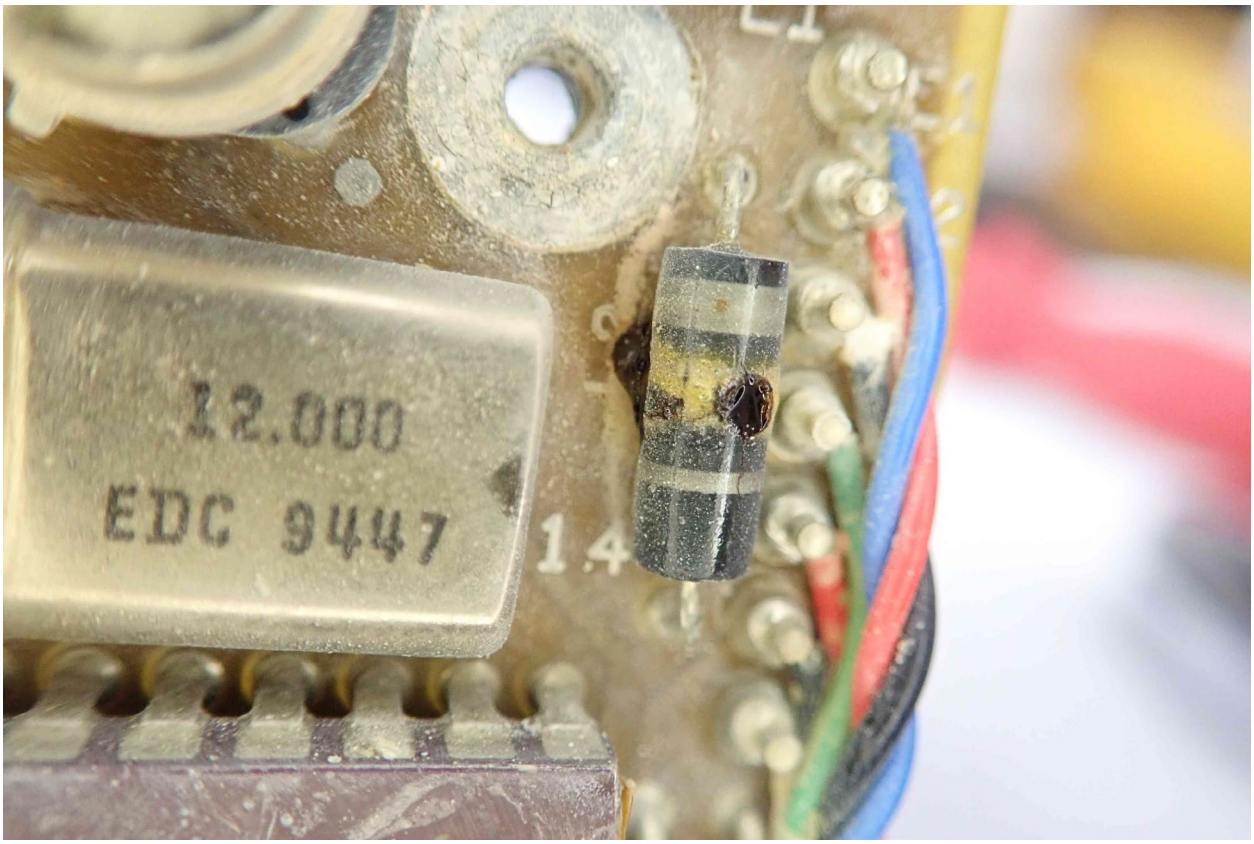

Figure 8 – L2 inductor

Submitted by: Eliott Simpson