

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



CEN23FA045

SYSTEMS

Group Chair's Factual Report

June 24, 2024

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A. ACCIDENT

Location: Mount Comfort, Indiana
Date: November 25, 2022
Time: 0800 eastern standard time
1300 coordinated universal time (UTC)
Airplane: Cirrus Vision Jet SF50, N15VJ, aircraft serial number 50-0215

B. SYSTEMS GROUP

Group Chair	John Flynn National Transportation Safety Board Washington, DC
Group Member	Partick Lusch Federal Aviation Administration Washington, DC
Group Member	Mel Crane Federal Aviation Administration Indianapolis, IN
Group Member	Brannon Mayer Cirrus Aircraft Duluth, MN
Group Member	Richard Kane VeriJet Holding Company, LLC Opa-locka, FL

C. SUMMARY

On November 25, 2022, about 0800 eastern standard time, a Cirrus SF50 airplane, N15VJ, was substantially damage when it impacted a retention pond after a deployment of the whole airplane parachute system near Mount Comfort, Indiana. The pilot was not injured. The flight was conducted under the provisions of Title 14 Code of Federal Regulations Part 91 as a positioning flight.

The Cirrus Airplane Parachute System (CAPS) control box assembly (part number 33264-003 Rev E, serial number 0247) and the electrical controller assembly (Part Number 35230-003) which contains the CAPS primary power holdover timer card assembly (Part Number 35595-001, serial number 0311) were removed from the aircraft for further testing.

D. DETAILS OF THE INVESTIGATION

1.0 Cirrus Airplane Parachute System

The CAPS is designed to lower the aircraft and its passengers to the ground in the event of a life-threatening emergency (Figure 1). The CAPS consists of four sub-systems:

- Activation system
- Extraction system
- Parachute system
- Harness system

The activation system includes the CAPS Activation Handle, located in the cabin ceiling on the airplane centerline just above the pilot's right shoulder, and the control box assembly (CBA), located in the aft avionics bay (Figure 2). The CAPS primary power holdover timer card is installed on the electrical controller assembly (ECA) (Figure 3) and provides primary power to the CBA once secondary power is energized and 1 hour thereafter. This is to ensure the CBA has power after an electrical failure but does not drain the aircraft battery between flights.

The extraction system includes a solid-propellant rocket to deploy the parachute, located immediately forward of the forward CAPS bulkhead, and an airbag with three inflators, located in the parachute bay.

The parachute is located immediately forward of the forward pressure bulkhead and covered by a carbon fiber frangible CAPS cover.

The parachute is a round canopy equipped with a slider (annular-shaped fabric panels with a diameter significantly less than the open diameter of the canopy). The slider has grommets spaced around its perimeter. Suspension lines are routed through these grommets so that the slider is free to move along the suspension lines. The slider is positioned at the top of the suspension lines near the canopy, reefing the canopy for initial deployment. During the reefed stage of deployment, the slider controls airflow into the canopy, helping with initial inflation, and then controlling the rate at which the canopy inflates. As airspeed decreases, the slider moves down the suspension lines, allowing for final inflation of the canopy.

The parachute itself is enclosed within a deployment bag that stages the deployment and inflation sequence. The deployment bag creates an orderly deployment process by allowing the canopy to inflate only after the rocket motor has pulled the parachute lines taut.

A three-point harness connects the airplane fuselage structure to the parachute. The forward harness strap is stowed in the parachute bay and attached to

the structure at the forward pressure bulkhead. The aft harness traps are attached near the wing root, routed along the fuselage under thin composite covers, and stowed in the parachute bay. When the parachute is extracted, the aft harness straps pull through the composite coverings from the parachute bay to the aft attach points.

Two separate and deliberate pilot actions are required to activate CAPS. The first action requires the pilot to pull the activation handle from its receptacle. The second action requires the pilot to clasp both hands around the activation handle and pull straight down. When the CAPS activation handle is pulled, the following CAPS activation sequence is initiated:

If the aircraft is in the CAPS deployment envelope, i.e., the aircraft speed is below 135 knots calibrated airspeed (KCAS) and 145 knots true airspeed (KTAS), the parachute will deploy.

If deployment is outside the envelope and initiation is delayed for autopilot to slow the aircraft, there is an 8 second speed check. At 8 seconds after handle pull, a check is performed to verify if airspeed has decreased; if it has not, CAPS is deployed. If a decrease has been detected, autopilot is allowed more time to decelerate; however, after 32 seconds, CAPS will deploy regardless of speed.

When the rocket launches, and initial pack movement initiates from three inflators fired in series, the parachute assembly is extracted outward due to rocket thrust and rearward due to relative wind. In approximately two seconds, the parachute will begin to inflate. When air begins to fill the canopy, forward motion of the airplane will dramatically be slowed. This deceleration increases with airspeed but in all cases within the parachute envelope should be less than 3 g. During this deceleration, a slight nose-up may be experienced, particularly at high speed; however, the rear riser is intentionally snubbed short to preclude excessive nose-up pitch. Following any nose-up pitching, the nose will gradually drop until the airplane is hanging nose-low beneath the canopy.

15 seconds after deployment, the rear riser snub line will be cut and the airplane tail will drop down into its final approximately level attitude. Once stabilized in this attitude, the airplane may yaw slowly back and forth or oscillate slightly as it hangs from the parachute. Descent rate is expected to be less than 1560 feet per minute with a lateral speed equal to the velocity of the surface wind. In addition, surface winds may continue to drag the airplane after ground impact.

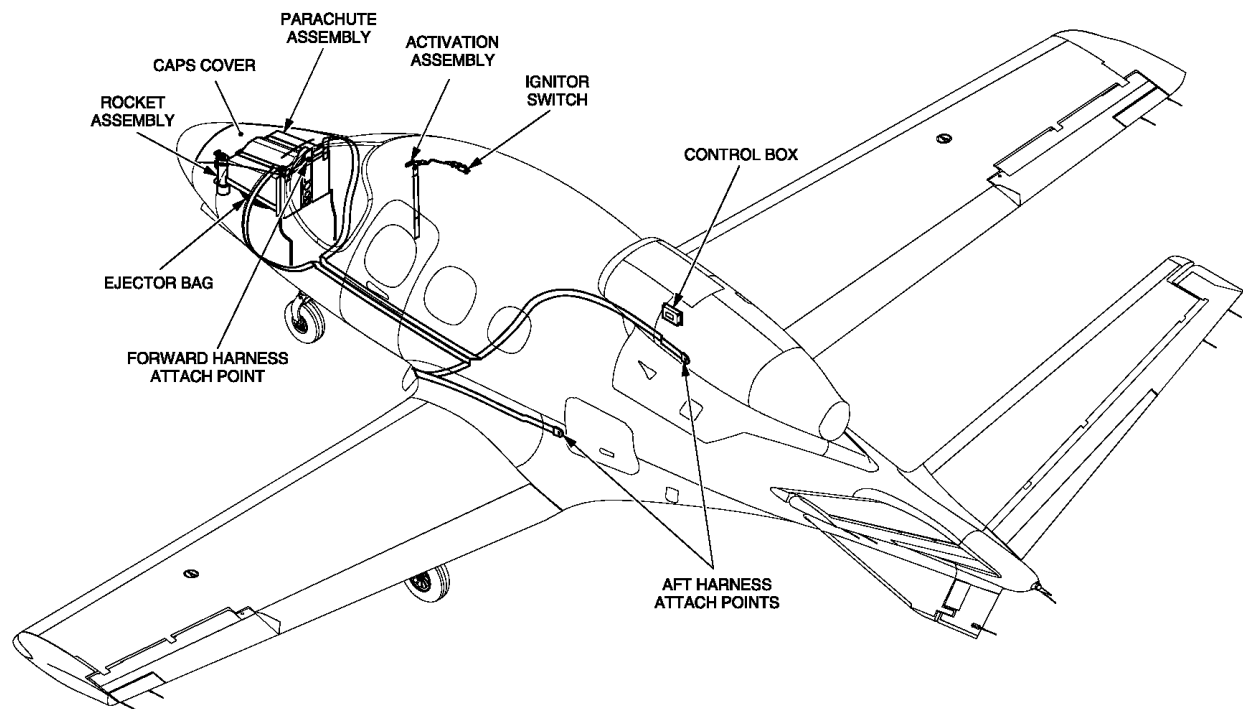


Figure 1. CAPS. (Courtesy of Cirrus Aircraft)

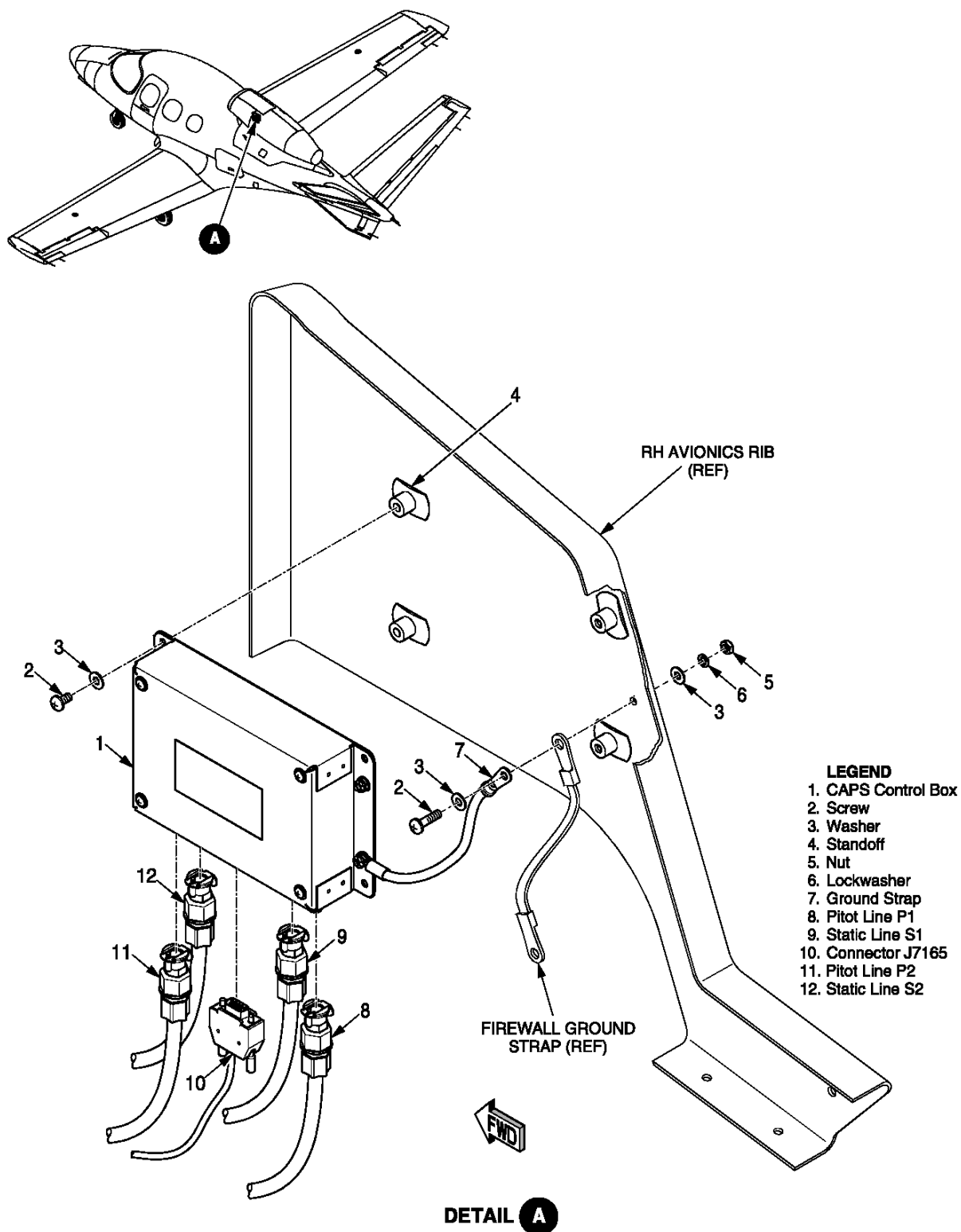


Figure 2. CAPS control box location. (Courtesy of Cirrus Aircraft)

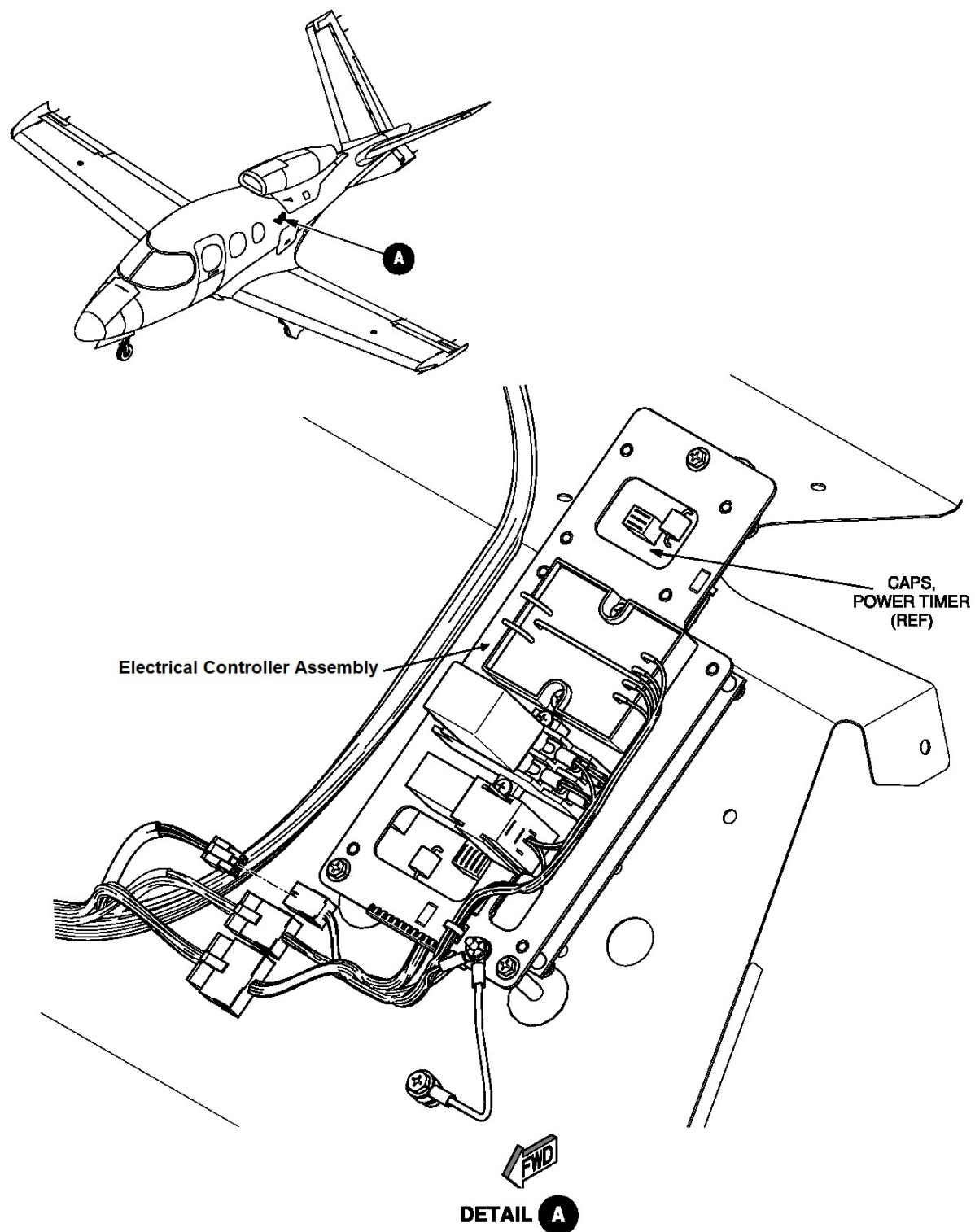


Figure 3. Electrical controller assembly showing the CAPS primary power holdover timer card location. (Courtesy of Cirrus Aircraft)

1.1 CAPS Autopilot Mode

The CAPS Autopilot Mode is engaged when the CAPS system activated signal is active and the autopilot is engaged or the altitude is greater than 200 feet above ground level (AGL). The CAPS autopilot (AP) mode is designed to rapidly raise the nose of the aircraft such that a swift deceleration occurs before deploying the parachute. Upon CAPS activation, the lateral and vertical flight director (FD) modes will change to CAPS/CAPS, and the autothrottle (AT) servo will engage, annunciated by AT in the AP mode annunciation panel (the active AT mode is also annunciated as CAPS).

The FD will command wings level and a nose high attitude of 30 degrees and the autothrottle will command idle thrust. The CAPS pitch response is limited by the pitch servo actuator to an absolute normal acceleration of 1.9 g's. Depending on airspeed and trim configuration upon activation, the airplane may not actually achieve this magnitude of an acceleration.

To expedite deceleration to within the CAPS deployment envelope in this emergency condition, under speed protection (USP) modes are inhibited while CAPS mode is active (this includes Throttle USP). Because of this, an alternate means of preventing stall during the deceleration is implemented as a normalized angle of attack (AOA) limit in CAPS mode. If the normalized AOA increases to above 0.8, the pitch FD command will decrease at a rate of 2 deg/sec until the normalized AOA falls below the respective threshold, or the pitch command reaches 0 degrees.

The parachute will deploy after the conditions have been achieved (typically 145 KTAS and 135 KIAS, but also time-triggered regardless of speed). The autopilot will continue commanding the nose high attitude until the indicated airspeed decreases to below 60 KIAS. At this point, the FD will command a zero-degree pitch angle. The autopilot servo actuators will remain engaged throughout the descent under canopy, or until the autopilot is disconnected.

If the discrete signal from the CAPS stays active, the AP will automatically try to re-engage into CAPS mode if it is disengaged. The pilot can override this capability by holding the AP DISC button down for 5 seconds continuously.

2.0 CAPS Primary Power Holdover Timer Card Visual Examinations

The electrical controller assembly which includes the CAPS primary power holdover timer card (also referred to as the CAPS timer card) was inspected at the NTSB on December 6, 2022. Residue was visible on the inductor of the CAPS timer card through the opening in the support (Figures 4 and 5). The CAPS timer card was removed from the electrical controller assembly to inspect it (Figure 6). The CAPS timer card was examined with an electronic microscope and pictures were taken of

areas with residue or corrosion (Figures 7 - 11). The following observations were made:

- 1) There was residue between pin 1, pin 2 and pin 4 of the J7240 connections on the printed circuit board (PCB) (Figure 7).
- 2) There was some residue by capacitor C3 and diode D1 (Figure 8).
- 3) There was residue and corrosion on top of the inductor as well as around it (Figure 9).
- 4) There appeared to be corrosion by capacitor C9 and diode D4 and there was residue and corrosion on integrated circuit 3 (IC3) and resistor 6 (R6) (Figure 10).
- 5) There was residue and/or corrosion around transistors Q1 and Q2, resistor R7, integrated circuit 4 (IC4), capacitor C7, IC1 and diode D2 (Figure 11).

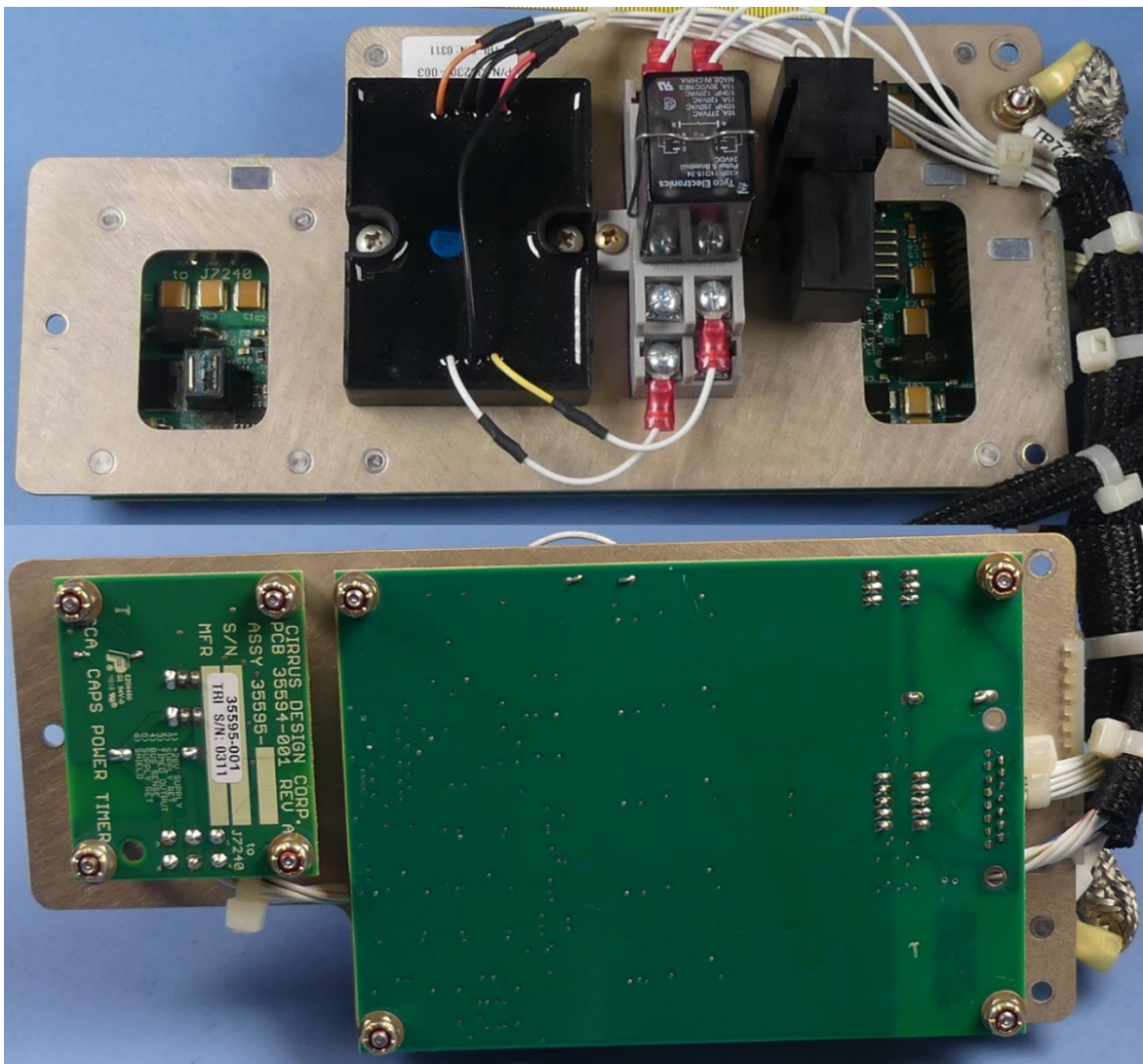


Figure 4. Photos of the electrical controller assembly.

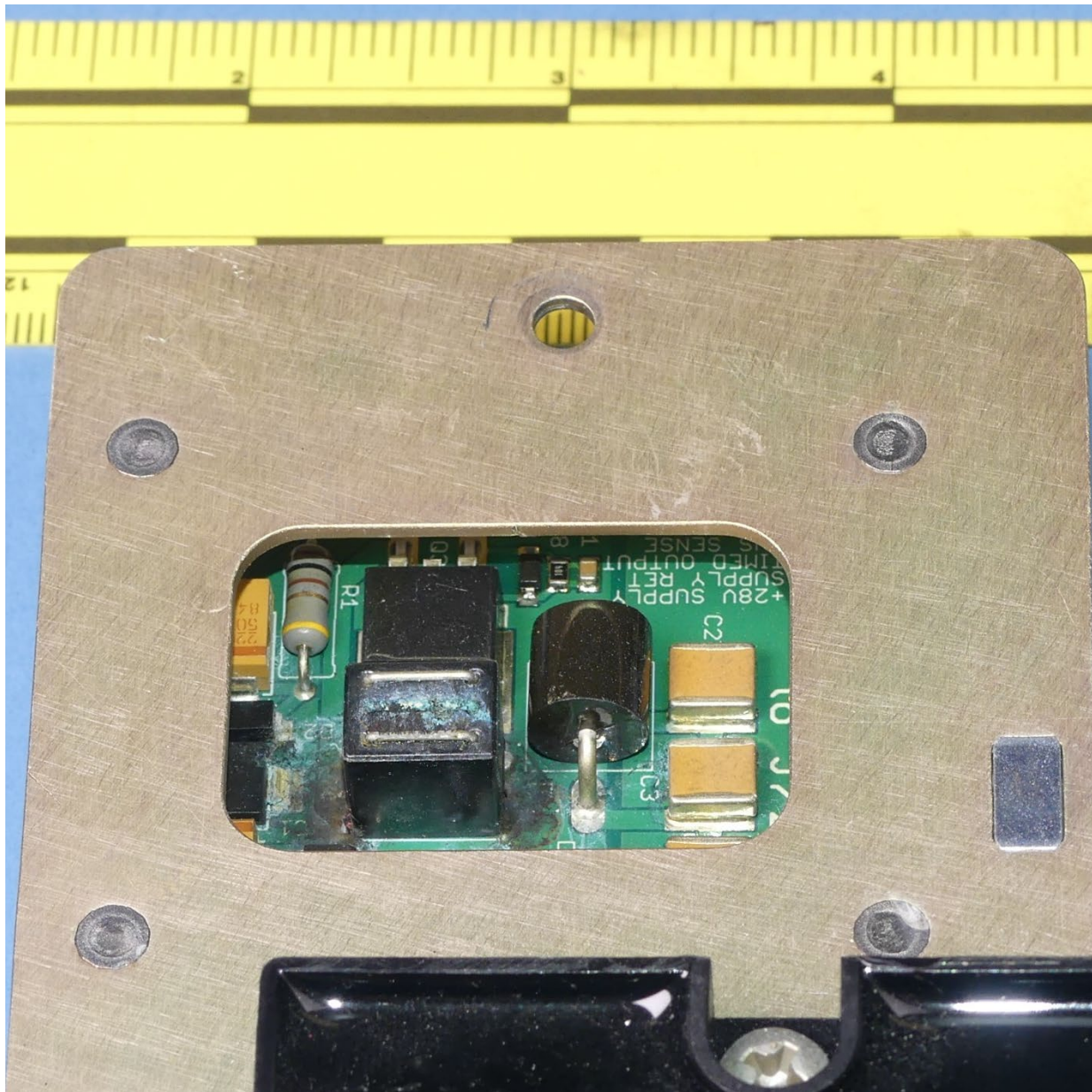


Figure 5. Photo of corrosion on the inductor of the CAPS primary power holdover timer card.

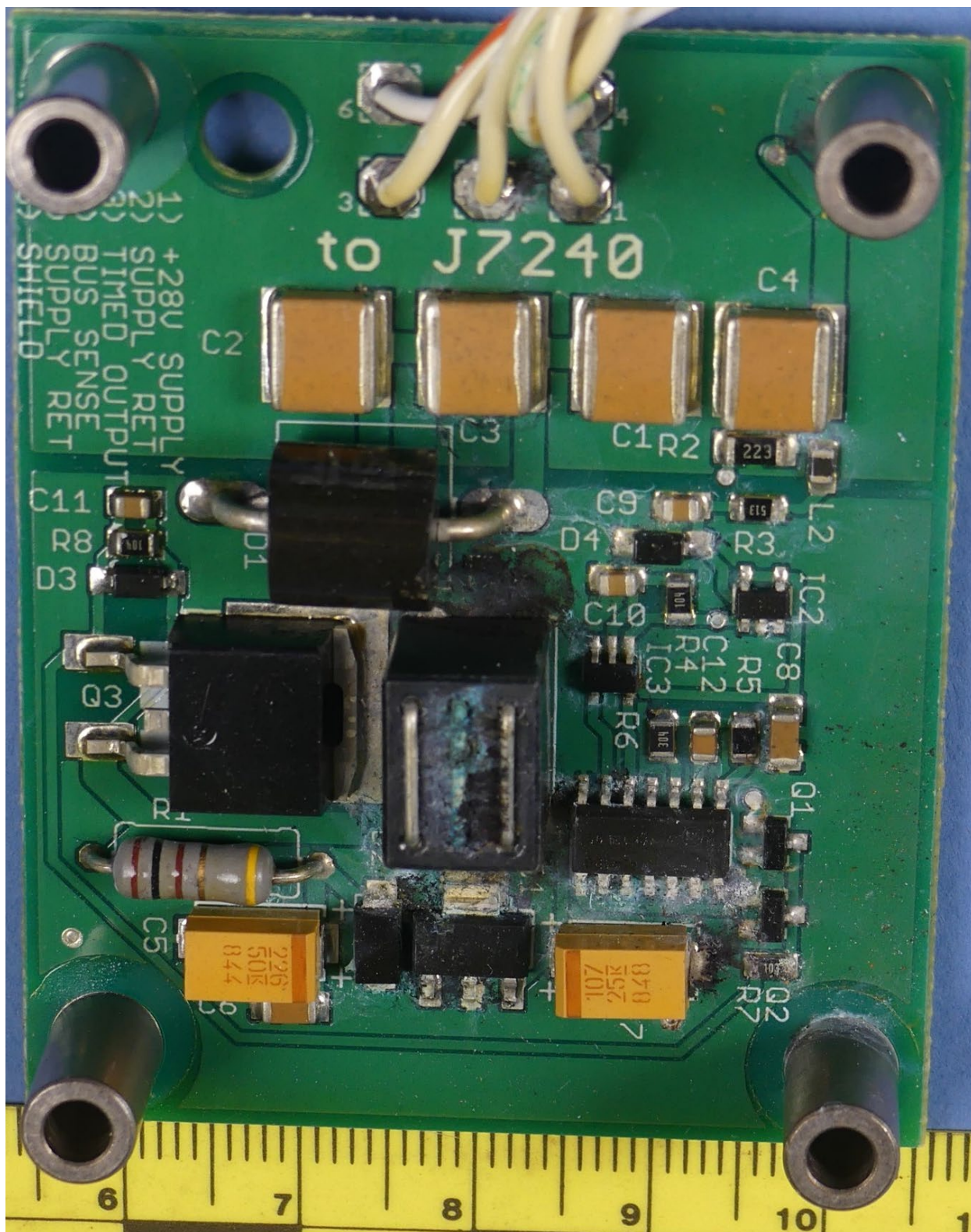


Figure 6. Photo of the CAPS primary power holdover timer card.

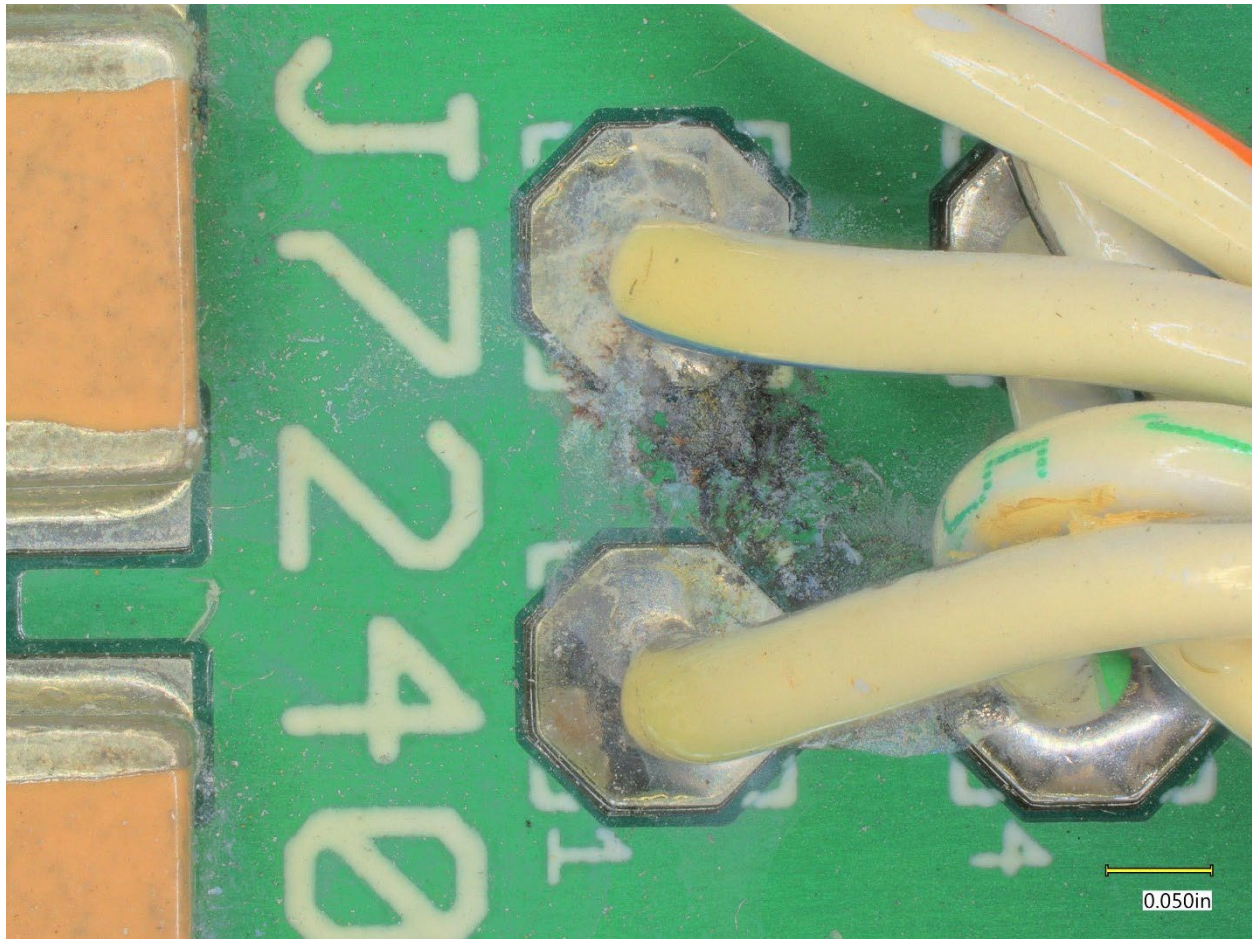


Figure 7. Photo of the J7240 connections on the CAPS primary power holdover timer card.

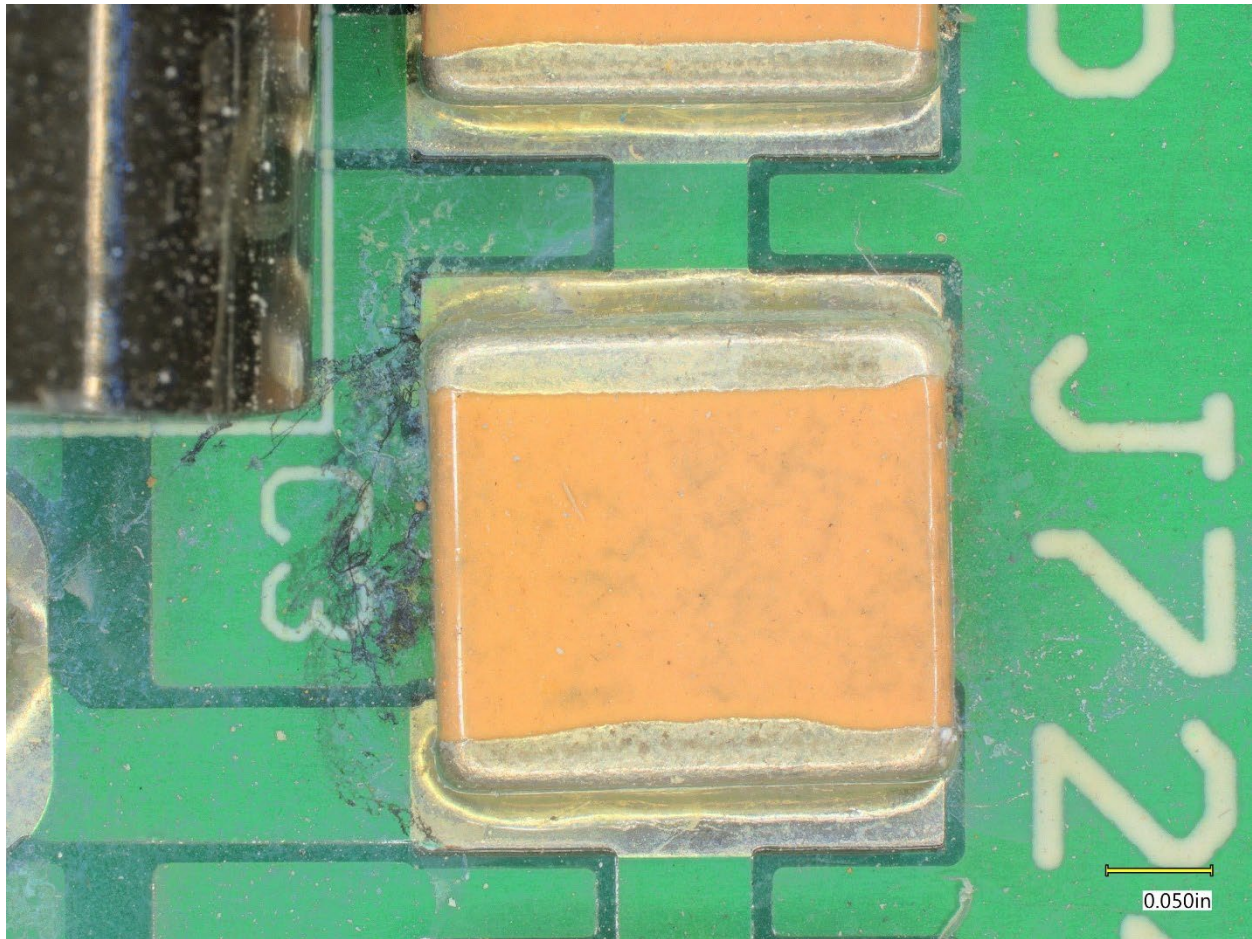


Figure 8. Photo of the area near the capacitor C3 and diode D1 on the CAPS primary power holdover timer card.

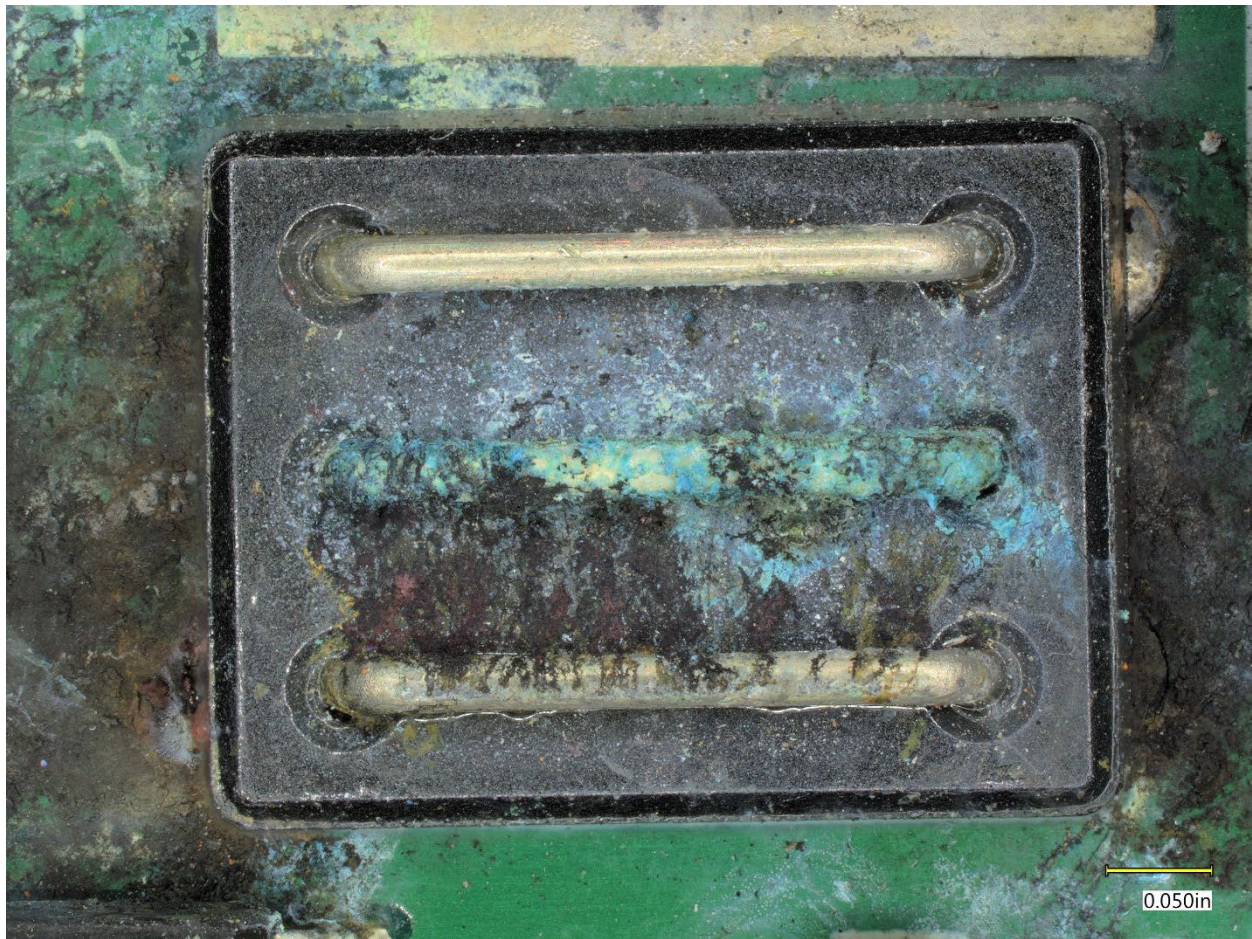


Figure 9. Photo of inductor and the area around it on the CAPS primary power holdover timer card.

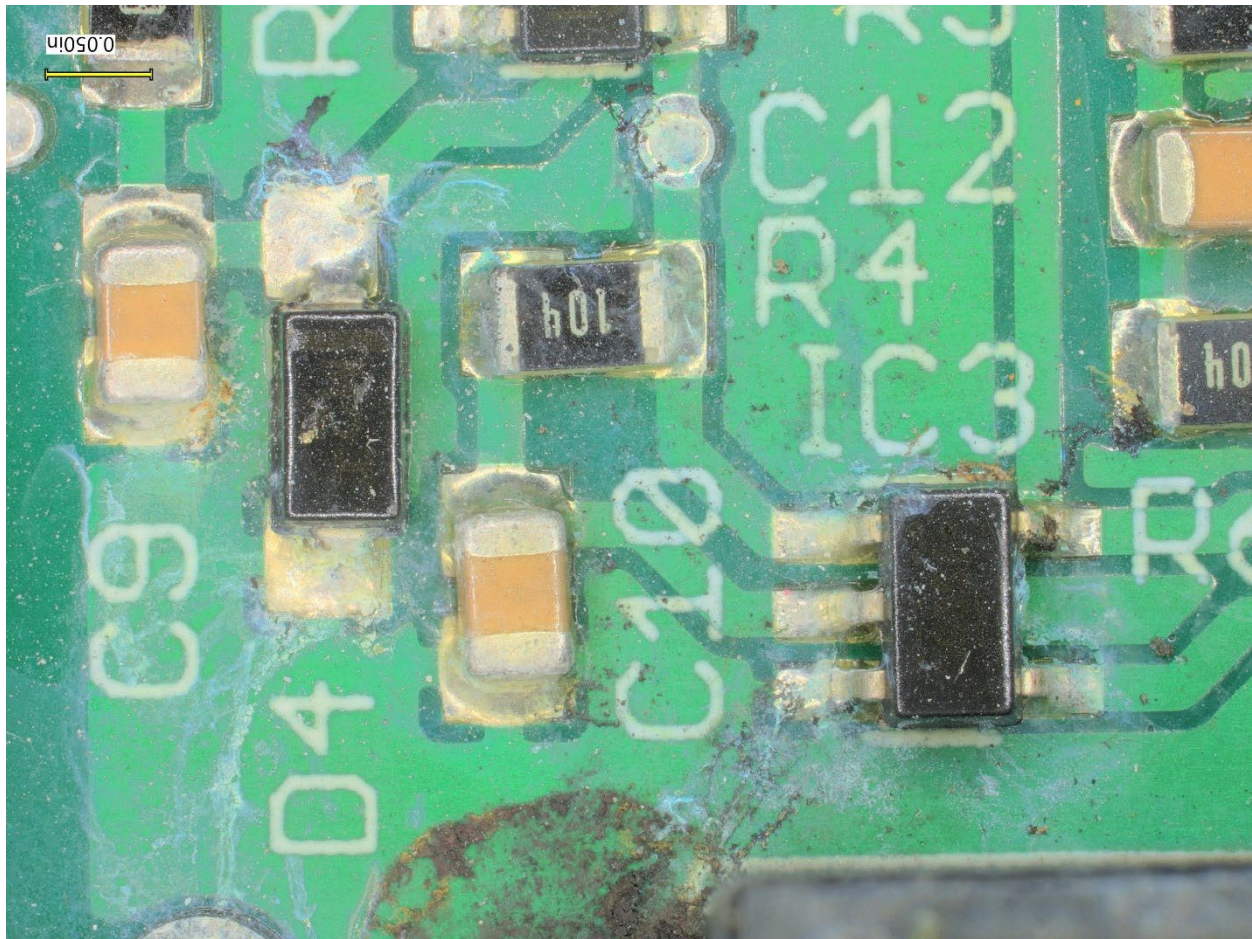


Figure 10. Photo of capacitor C9, diode D4, integrated circuit IC3 and resistor R6 on the CAPS primary power holdover timer card.

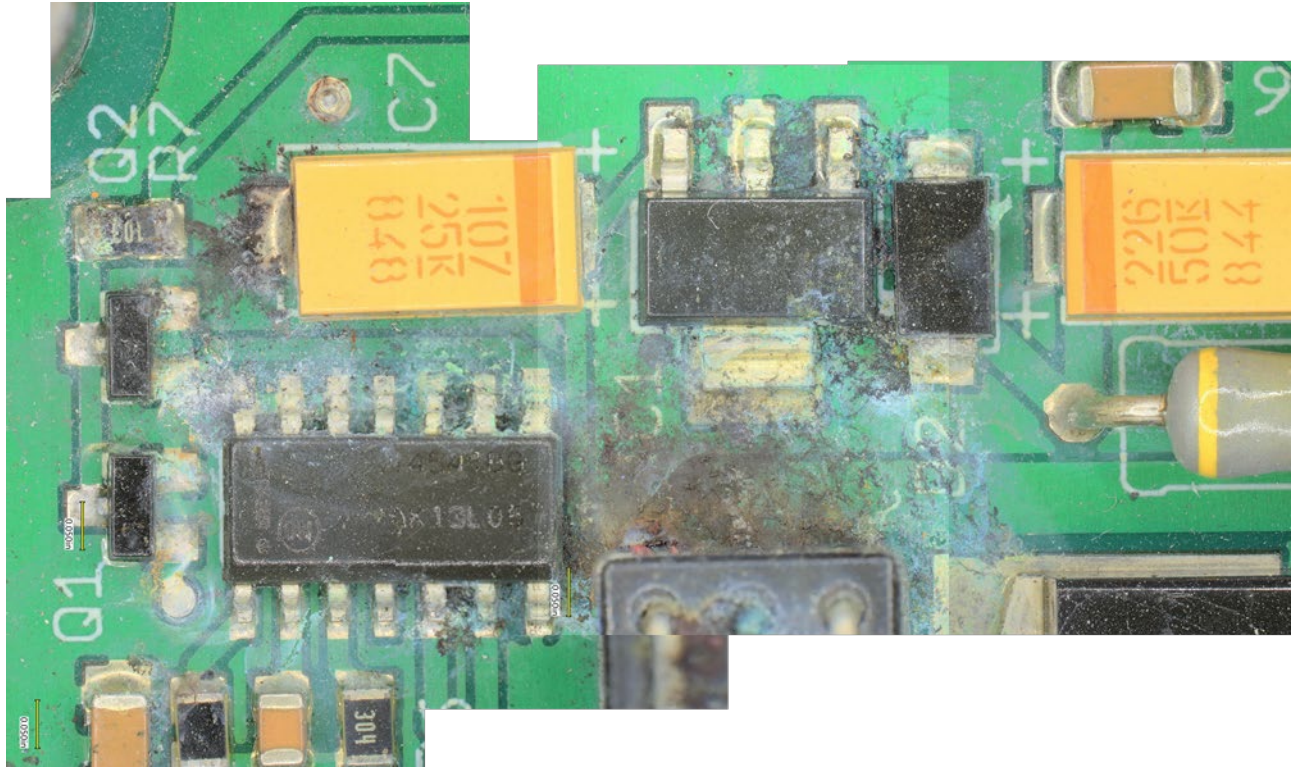


Figure 11. Composite of photos of the area around transistors Q1 and Q2, resistor R7, integrated circuit IC4 and IC1, capacitor C7 and diode D2 on the CAPS primary power holdover timer card.

3.0 CAPS Primary Power Holdover Timer Card Testing

The CAPS primary power holdover timer card was tested at Cirrus Aircraft on May 3, 2023. Continuity checks were performed between various pins on the J2740 connector with the multimeter. The tests verified that pins 2 and 5 were electrically connected with a resistance of 0.3 Ohms. The resistance was measured between pins 4 and 5 and the resistance was 22k Ohms. A continuity check was performed between pin 6 and the exposed hardware frame. It was verified that pin 6 and the hardware frame were electrically connected and the resistance was 0.1 Ohms. All checks passed.

The CAPS primary power holdover timer card was connected to the T165795 test box using an adapter harness (Figure 12). An oscilloscope was connected to pins 2 and 3. All switches on the T165795 test box were set to the "OFF" position and it was plugged into an outlet.

The T165795 test box was set as specified: Switch S1 (ON/OFF) was set to the "ON" position and verified that light emitting diode 1 (LED1) (ON/OFF) illuminated. Switch S2 (primary power (PRI PWR)) was set to the "ON" position and verified that LED2 (GROUND LOOP) and LED3 (PRI PWR) illuminated. Switch S3 (Secondary Power (SEC PWR)) was set to the "ON" position and verified that LED4 (SEC PWR) illuminated. Switch S3 (SEC PWR) was set to the "OFF" position and waited

approximately 60 minutes and verified that LED3 (PRI PWR) extinguished. This verified that the CAPS primary power holdover timer card would provide power to the CBA for 60 minutes after secondary power was turned off.

The CAPS primary power holdover timer card passed all the electrical tests.

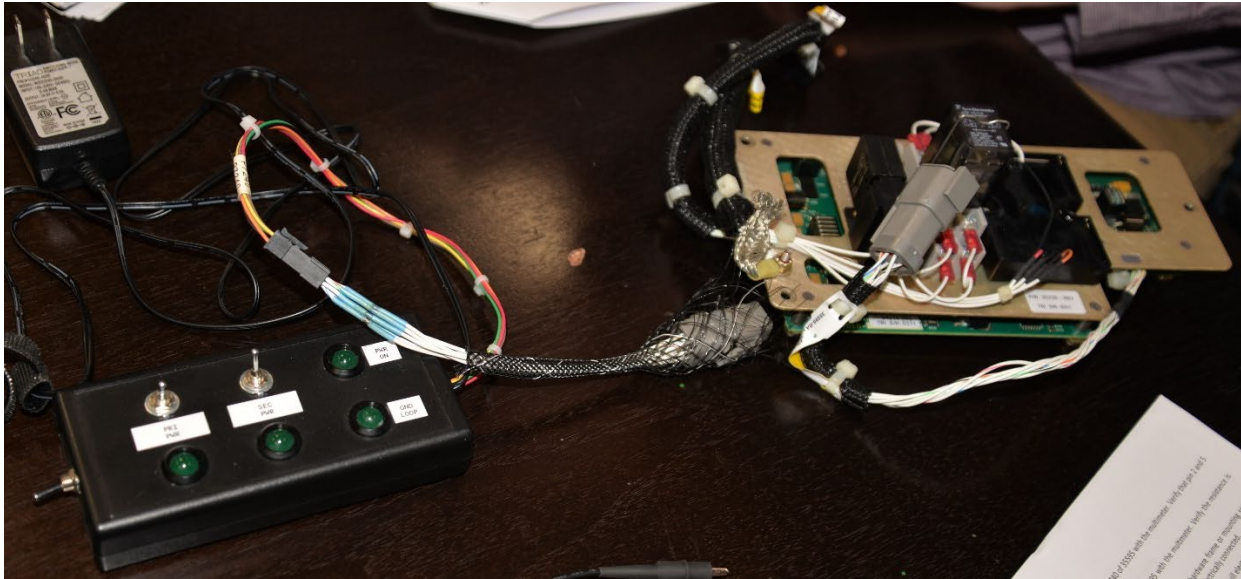


Figure 12. Photo of the CAPS primary power holdover timer card test set-up.

4.0 CAPS Control Box Assembly Testing

The CAPS CBA (Figure 13) was tested at Cirrus Aircraft on May 3, 2023. The CAPS CBA was installed in a test fixture (Figure 14). The “CAPS activated” signal was output at connector J7165 pin 6. Pin 6 outputs approximately 5 volts direct current (VDC) when the CAPS is NOT activated and approximately 0 VDC when CAPS is activated.

4.1 Primary Power Interruption

The CAPS CBA input power was connected to an interrupting switch. While holding the interrupting switch in the starting closed position, pin 6 was at approximately 5 VDC (4.77 VDC actual) indicating a normal state. The technician quickly slid the movable switch contact across insulating gaps to produce interrupted input voltage and stopped at a closed switch position. Pin 6 output switched low and remained near ground (0.11 VDC) indicating the “CAPS Activated” signal was active and latched. This demonstrated that a short interruption in the primary power to the CBA could cause an erroneous “CAPS Activated” signal to be generated and latch. This was repeated a few times and the waveform was captured on an oscilloscope (Figure 15).



Figure 13. Photo of CAPS CBA.

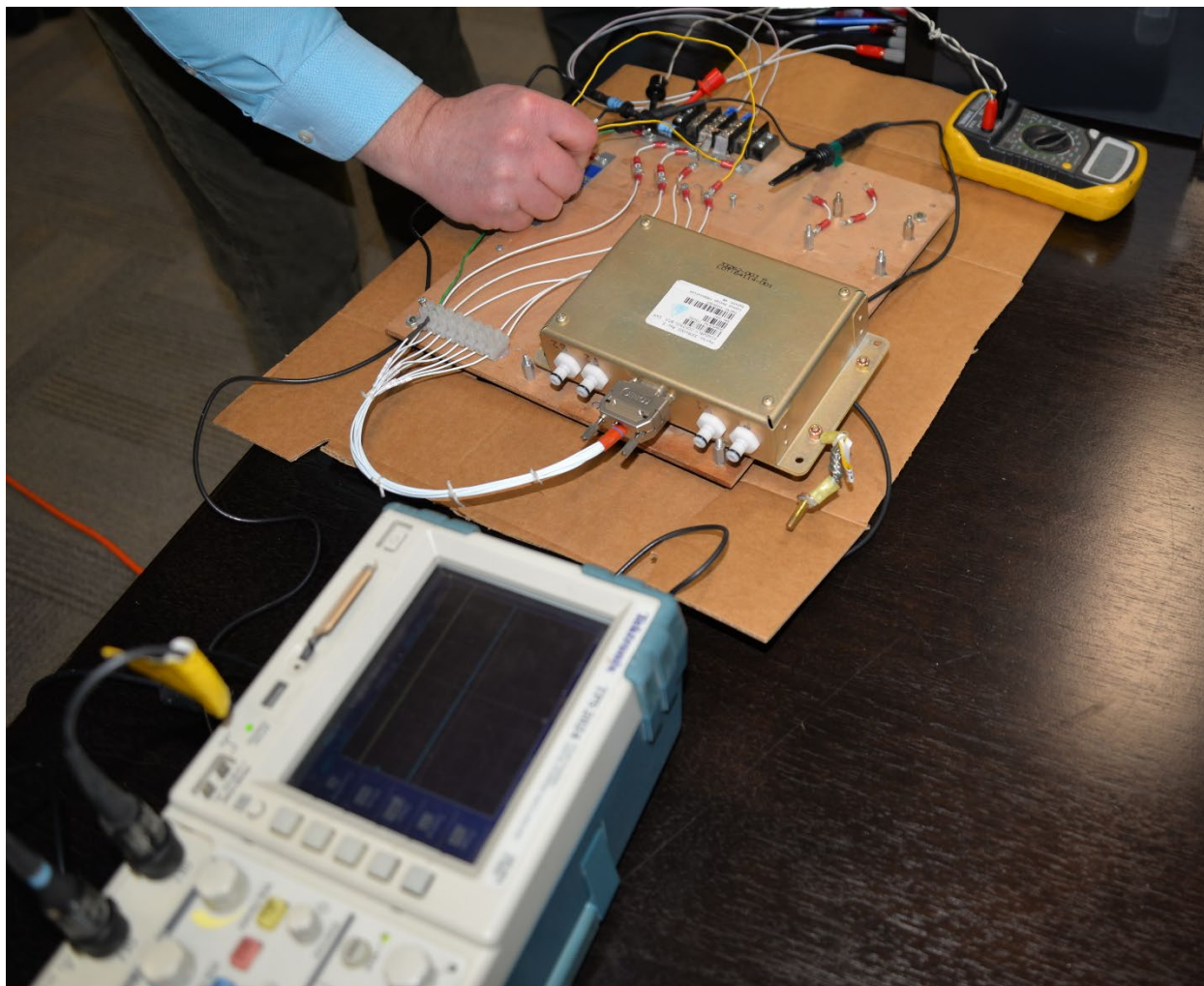


Figure 14. Photo of CAPS CBA attached to test fixture.

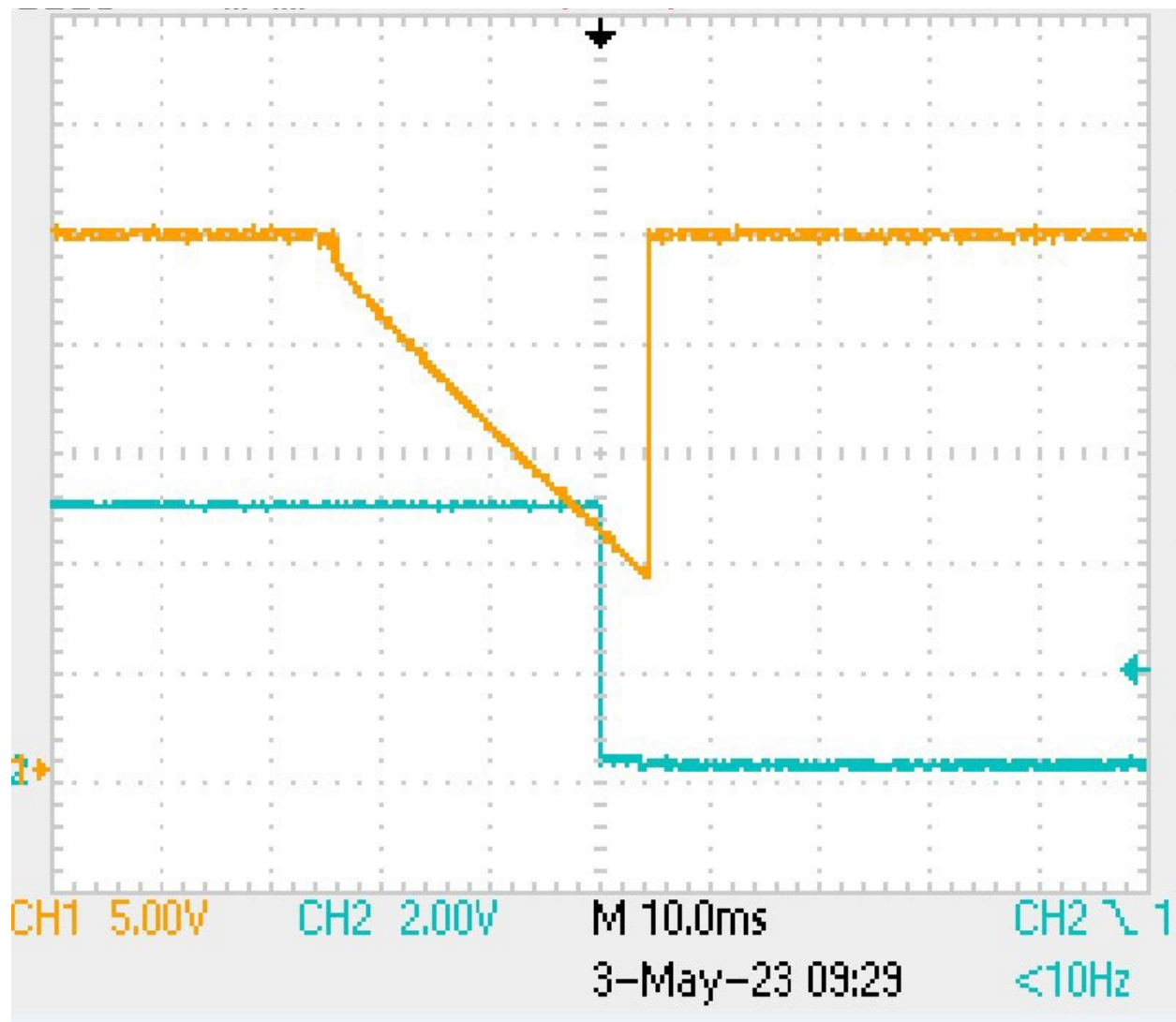


Figure 15. Photo of waveform from primary power interruption.

Figure 15 detailed description: The orange line is the primary power into the CBA. The value started at approximately 25 VDC. The blue line is the "CAPS Activated" signal sent from the CBA to the autopilot. The value started at 4.77 VDC and this corresponds to CAPS not activated. When the power was interrupted and the voltage dropped from 25 VDC to 11 VDC, the "CAPS Activated" signal changed from 4.77 VDC to 0.11 VDC indicating the CAPS was activated. The primary power returned to 25 VDC but the "CAPS Activated" signal stayed latched and the value remained near 0.11 VDC.

4.2 Primary Ground Interruption

The CAPS CBA primary return (pin 7) was connected to an interrupting switch. While holding the interrupting switch in the starting closed position, pin 6 was at approximately 5 VDC (4.77 VDC actual) indicating a normal state. The technician quickly slid the movable switch contact across insulating gaps to produce interrupted return or ground and stopped at a closed switch position. Pin 6 output switched low and remained near ground (0.11 VDC) indicating the "CAPS Activated" signal was active and latched. This demonstrated that a short interruption in the primary ground to the CBA could cause an erroneous "CAPS Activated" signal to be generated and latch. This was repeated a few times and the waveform was captured on an oscilloscope (Figure 16).

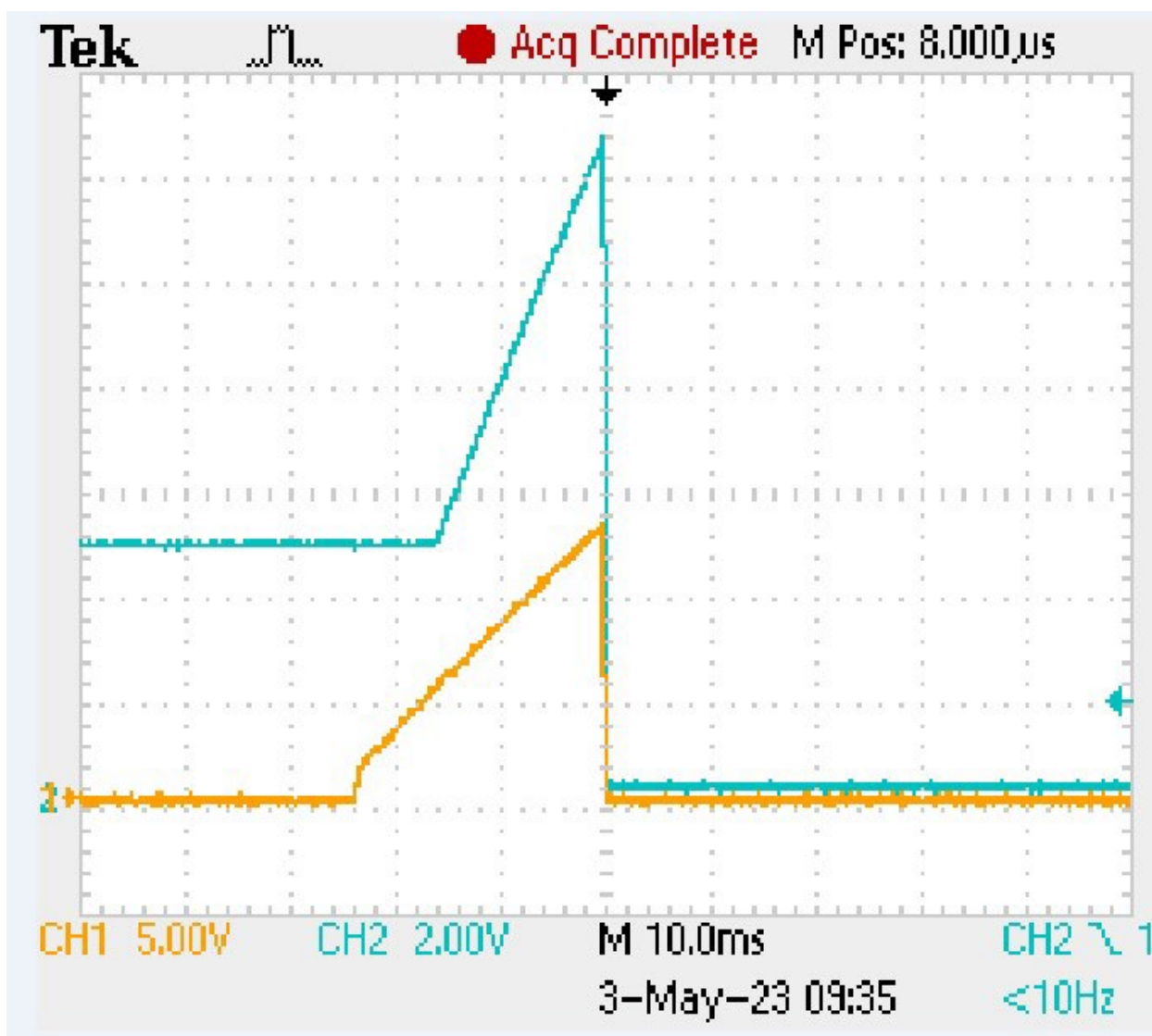


Figure 16. Photo of waveform from primary ground interruption.

Figure 16 detailed description: The orange line is the primary ground voltage into the CBA. The value started at approximately 0 VDC. The blue line is the "CAPS Activated" signal sent from the CBA to the autopilot. The value started at 4.77 VDC and this corresponds to CAPS not activated. When the primary ground was interrupted and the voltage increased from 0 VDC to 14 VDC, the "CAPS Activated" signal changed from 4.77 VDC to approximately 12.5 VDC then dropped to 0.11 VDC indicating the CAPS was activated. The primary ground returned to 0 VDC but the "CAPS Activated" signal stayed latched and the value remained near 0.11 VDC.

4.3 Secondary Ground Interruption

The CAPS CBA secondary return (pin 8) was connected to an interrupting switch. While holding the interrupting switch in the starting closed position, Pin 6 was at approximately 5 VDC (4.77 VDC actual) indicating a normal state. The technician quickly slid the movable switch contact across insulating gaps to produce interrupted return or ground and stopped at a closed switch position. Pin 6 output switched low and remained near ground (0.11 VDC) indicating the "CAPS Activated" signal was active and latched. This demonstrated that a short interruption in the secondary ground to the CBA could cause an erroneous "CAPS Activated" signal to be generated and latch. This was repeated a few times and the waveform was captured on an oscilloscope (Figure 17).

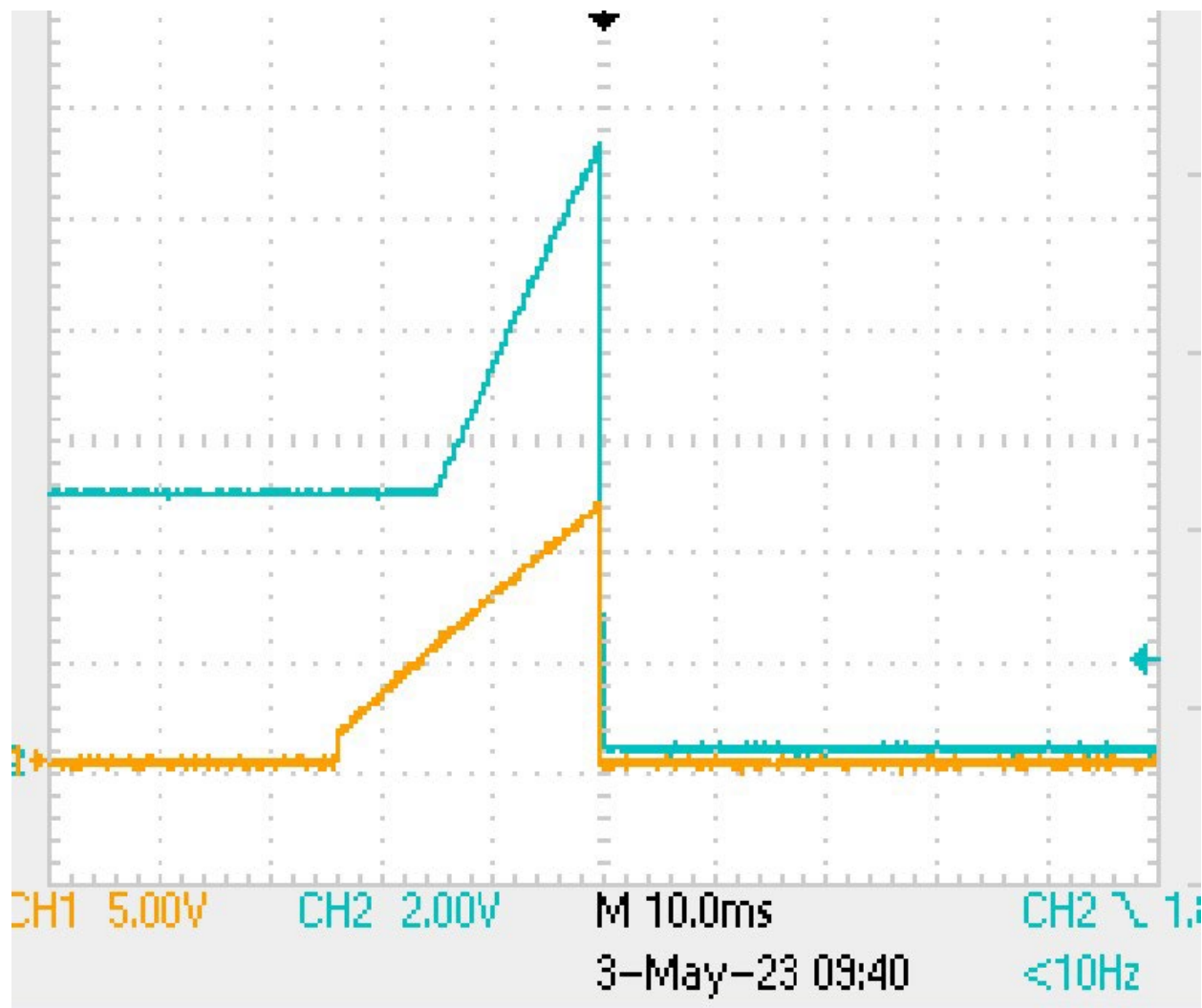


Figure 17. Photo of waveform from secondary ground interruption.

Figure 17 detailed description: The orange line is the secondary ground voltage into the CBA. The value started at approximately 0 VDC. The blue line is the "CAPS Activated" signal sent from the CBA to the autopilot. The value started at 4.77 VDC and this corresponds to CAPS not activated. When the primary ground was interrupted and the voltage increased from 0 VDC to 12 VDC, the "CAPS Activated" signal changed from 4.77 VDC to approximately 11 VDC then dropped to 0.11 VDC indicating the CAPS was activated. The primary ground returned to 0 VDC but the "CAPS Activated" signal stayed latched and the value remained near 0.11 VDC.

E. HISTORY OF THE ISSUE

1.0 Previous Caps Activated Event

In 2017, aircraft serial number 50-0023 reported a false CAPS Activated CAS message. Investigation found the cause to be an intermittent contact at the CAPS holdover timer connector (P/J7240). That problem was corrected by changing to a more robust connector. Reference Repair/Alteration RA00010295 and Service Bulletin SB5X-90-05.

2.0 Previous Water Intrusion into the Baggage Compartment

In earlier Vision Jets, Cirrus Aircraft received reports of wet baggage compartments due to leaks from various areas in the compartment. The areas were 1) under inlet antenna cables pass through hole (fixed per SB5X-53-10); 2) baggage door seal and handle (fixed per SB5X-52-08); 3) aft bulkhead gaps (fixed per SB5X-53-10); and 4) engine nacelle panels cam locs (fixed per SB5X-53-10). SB5X-52-08 was issued in June 2019 and SB5X-53-10 was issued in October 2019. The accident aircraft was produced after these service bulletins were released, and therefore the associated leaks were addressed during manufacture.

3.0 CAPS Primary Power Holdover Timer Card Corrosion History

After the CAPS primary power holdover timer card from aircraft 50-0215 was found with corrosion, Cirrus Aircraft asked the operators to check their aircraft. They found 27 aircraft with corroded CAPS primary power holdover timer cards.

F. CHANGES IMPLEMENTED TO ADDRESS THE POWER INTERRUPTS AND THE CORROSION

1.0 Redesigned CAPS CBA

Cirrus Aircraft is changing the circuits in the CAPS controller box by adding resistors and capacitors so that neither power nor ground transients (Reference Section D.4) will trigger a nuisance CAPS activated signal. The redesigned circuits were tested and compared to the current design. A sample of this is shown in Figure 18 below.

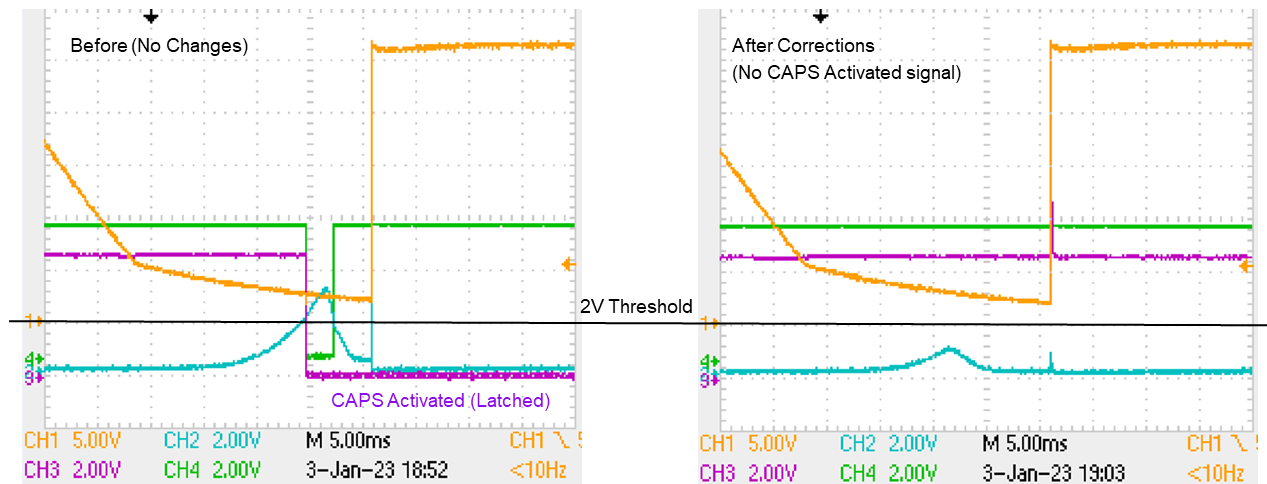


Figure 18. Comparison between the current CAPS CBA and the redesigned CAPS CBA.

2.0 Enclosure for CAPS Primary Power Holdover Timer Card

Cirrus Aircraft is enclosing and potting the CAPS primary power holdover timer card to protect against corrosion. Potting the CAPS primary power holdover timer card will eliminate the potential of any moisture causing power fluctuations.

Submitted by:

John Flynn
Aircraft Systems Investigator