

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR24LA265

MGT INDICATOR EXAM

April 9, 2025

A. ACCIDENT

Location: Raft River, Idaho
Date: August 2, 2024
Helicopter: Bell 407, N20BH

B. MGT INDICATOR EXAM

IIC	Elliott Simpson NTSB
Specialist	Joseph Krist Air Dallas Instruments, Inc

C. SUMMARY

The unit was examined and tested, with no anomalies noted. It was found that the error observed during the accident sequence (increasing MGT, accompanied with random screen characters, followed by a bit-check/reboot) could be simulated by lowering the supply voltage down to 6v, and then returning it to the nominal supply of 28v.

The unit recorded one exceedance, the timing which appeared to match the accident flight.

D. DETAILS OF THE EXAMINATION

1.0 System Design and Unit History

Bell Part Number: 407-375-001-005
Serial Number: 0541

According to representatives from Air Dallas Instruments (ADI), the MGT unit is comprised of a liquid crystal diode (LCD) display, driven by a series of display drivers. A main processor (CPU) manages the system and provides data to display processors which control the display drivers. Internal supply voltage is provided by multiple voltage regulators, each driving the different internal systems.

The CPU is controlled by a clock that is regulated by a crystal oscillator. A "supervisory" processor monitors both the clock output and regulator voltages and is designed to issue a reboot command to the main CPU if any values are out of limits. The supervisory processor does not control the display processor or drivers. Input

signals from the engine-mounted thermocouple are monitored by a series of filters, designed to block spurious input signals.

ADI records indicated that the unit came for repair on March 20, 2013, from the MRO, Precision Heliparts. It was reported as having a bad LCD display, which was cracked and delaminated. ADI did not open or repair the unit because they do not have the components to perform such work. Therefore, the unit was returned with a recommendation that Bell Helicopters perform the repair.

The unit then came back to ADI on April 5, 2013, this time from Trade Wind International with the same repair request. ADI sent it back again with the same repair recommendations.

The data tag indicated that the unit was manufactured in the 22nd week of 2000. It had a manufacturer's seal that appeared to be the original type. ADI typically repairs between 20 to 30 of these units per month. Typical errors include problems with screen segments failing (often due to bad connections between the display and the display drivers), dry solder joints to the processor or CPU clock crystal oscillator, and memory battery replacement.

The ADI representative reported that he has never seen an error like the one observed during the accident sequence.

2.0 Examination

The unit was externally examined and appeared undamaged. The power connector pins were intact and clean. The unit was then connected to a test bench that was comprised of a power supply and a thermometer calibrator. The system was powered, and ADI PS9009001 test protocol was followed.¹

The unit booted up normally, and all display segments appeared operational during the power-up bit check. An "E" appeared on the numeric temperature display. The numeric display indicated 498° C (the input value was set to 500 °C at the thermocouple pin). Variations to the thermocouple input via the calibrator resulted in appropriate movement of the temperature segments and numeric display.

The design of the unit was such that if the indicator segments are in the yellow region for 270 seconds the display will flash, and after 300 seconds the numeric display will show an "E" indicating an exceedance has been recorded. If the temperature climbs above the red region for more than 10 seconds an exceedance will be triggered, and if the temperature exceeds the red triangle, an exceedance will be immediately

¹ The protocol had last been reviewed on January 25, 2025.

triggered. The exceedance flag cannot be reset without external intervention from a mechanic.

The unit's memory was accessed using the standard maintenance software, and one exceedance had been recorded (the unit is capable of recording 50 exceedances).

The exceedance was 737 °C and lasted 5 seconds. It was recorded on August 2, 2024, at 1931:56².

The unit was then operated for about 15 minutes during which time it was cycled through three exceedance (yellow band) cycles. The display worked appropriately and responded to changes in input voltage.

The unit was then disassembled and examined. There was no evidence of dry solder joints, burnt components or damaged wires (see figure 1). It was powered up and tested while multiple components including the crystal oscillators, CPU, and supervisory processor were pressed with a probe in an attempt to induce an error³. The unit performed appropriately throughout.

The only physical discrepancy noted was to pin 4 (frequency output pin) of the crystal oscillator. A blob of solder had bonded to the gold edge of the oscillator case next to that pin (figure 2). Electrical continuity was tested between the case and the pin, with no evidence of a short circuit⁴.

The oscillator output was tested and was found to be 11.05kHz, which was within range because its nominal value, which was 11.059khz. The supervisory processor was tested and issued a CPU reboot command at its control pin when triggered.

The unit was then fitted to a vibrating table and tested for 30 minutes through multiple thermocouple input range cycles. The unit performed appropriately throughout.

The final test performed was to see how the unit would perform as its supply voltage was lowered. The starting voltage was 28v, and as it was reduced though to 12v the display began to dim. At 6v the indicator value began to climb over the red line limit (figure 3). Four tests were performed, and on the last test after the indicator values began to climb, the numeric display showed random characters, and segments of the

² The units clock date matched the current date, except that the clock was about 40 minutes offset (slower) relative to MDT.

³ According to the ADI representative, pressing components while the system is running is a standard trouble shooting technique for testing dry or loose solder joints - a common point of failure in these systems.

⁴ Post-exam testing on an exemplar unit revealed that if the case is shorted to the pin the unit will stop operating and reboot.

indicator began to turn off (figure 4). As the voltage continued to be reduced, the unit shut down, and once power was reapplied, it performed a bit check and returned to the normal reading.

Based on this finding, the power regulators were checked for heat damage⁵ and dry solder joints. All were intact, and the system worked normally when each regulator was pushed with a probe.

The memory battery voltage was tested, and had a potential difference of 2.7v the nominal voltage is 3.3v.

3.0 Exam Photos

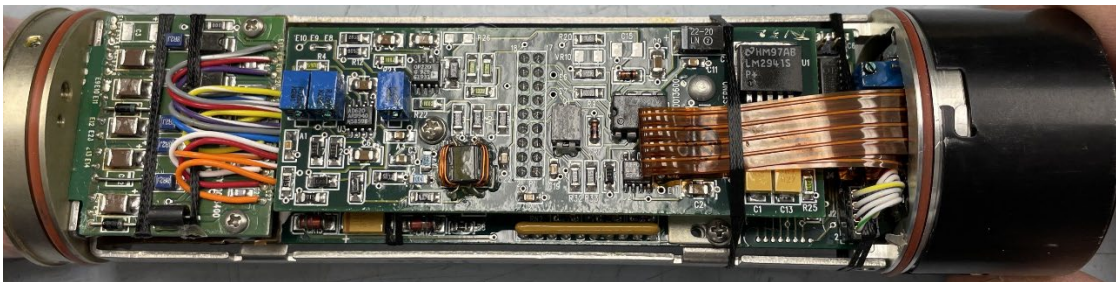


Figure 1 - Indicator with case removed

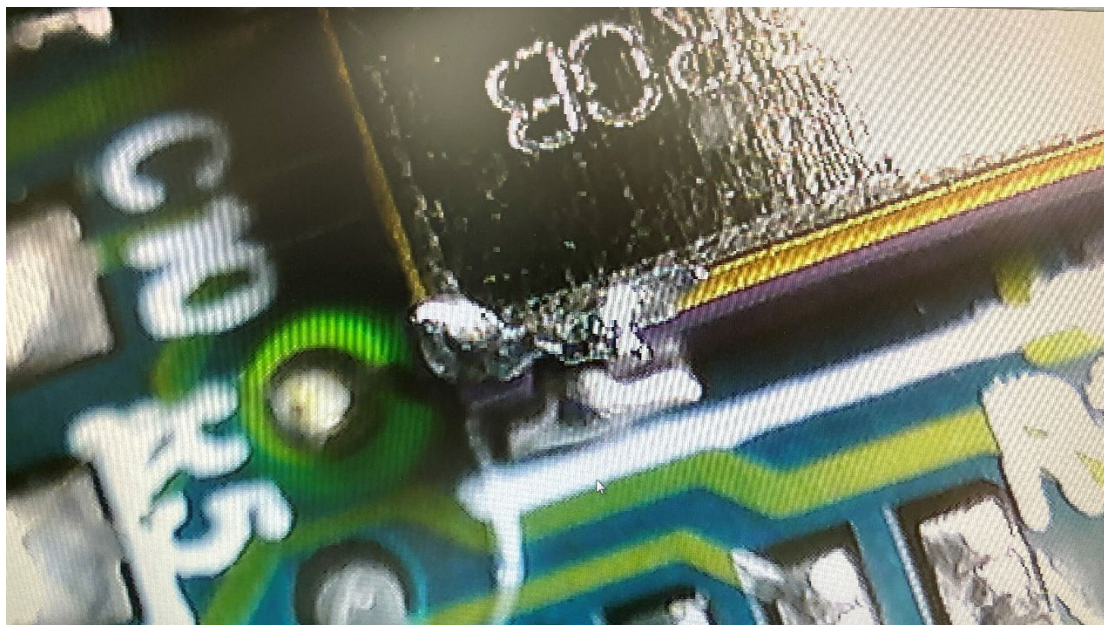


Figure 2 - Solder "blob" on crystal oscillator case just above pin 4

⁵ The area of the printed circuit board under the power regulators was brown rather than the green as on the rest of the board. According to the ADI representative, this is normal, and a function of the heat emitted by the regulators during normal operation. The ADI representative noted that the discoloration was far less severe than that observed on most units that come in for service.



Figure 3 - MGT value increasing as supply voltage drops below 6v



Figure 4 - Random screen characters as supply voltage drops below 6v

Submitted by:

Elliott Simpson
Senior Aviation Accident Investigator