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Basic Troubleshooting CAN Bus Communications on certain Caterpillar Telehandlers.

Note: *This revised publication replaces the June 29, 2012 special instruction. Corrections have been made to the tables on the resistance measurements C & D.*

Introduction:

This special instruction provides Basic information for troubleshooting the CAN communication.

Applicable to:

These troubleshooting guidelines are applicable to Caterpillar Telehandlers with the following serial numbers:

Model	Applicable Serial Number Range
TH336	TDE00100 – Up
TH337	TDF00100 – Up
TH406	TBX00100 – Up
TH407	TBY00100 – Up
TH414	TBZ00100 – Up
TH514	TBW00100 – Up
TH417	TBT00100 – Up

Definition of CAN Bus:

Controller Area Network (CAN) is a serial bus that connects multiple electronic control modules (ECM's) or components together to send or receive messages in order to facilitate correct machine/engine operation. This data link consists of two copper wires twisted as a pair, with approximately one twist per inch (40 twists per meter). Often this twisted pair is shielded, but not always. One wire of the pair is designated as CAN High (+), and the other wire is designated as CAN Low (-). CAN data link transfers real time communication between control units (ECM's, displays, service tools, and other components that require network communication for proper operation.

CAN is a simple two-wire differential serial bus—information is transferred using a differential voltage between CAN High and CAN Low. Voltages of both CAN High and CAN Low are relative to shield or ground.

CAN busses can have one of two logic states—dominant and recessive. Typically, the voltage level associated with recessive (logic state "1") is 2.5 V for CAN High and Low. Voltage levels for dominant information (logic state "0") are 3.5 V~4.5V for CAN high and 0.5~1.5 V for CAN low. The voltage level on the bus is recessive (2.5 V) when the bus is idle.

Components or Control Units Linked to CAN bus.

The TH product is equipped with two CAN bus channels, CAN 1 & CAN 2, both linked to the UGM which is the master controller and gateway between CAN 1 & 2.
CAN Bus channel 2 is only used on platform ready machines.
Components or Control units displayed in dashed boxes are optional or model specific.

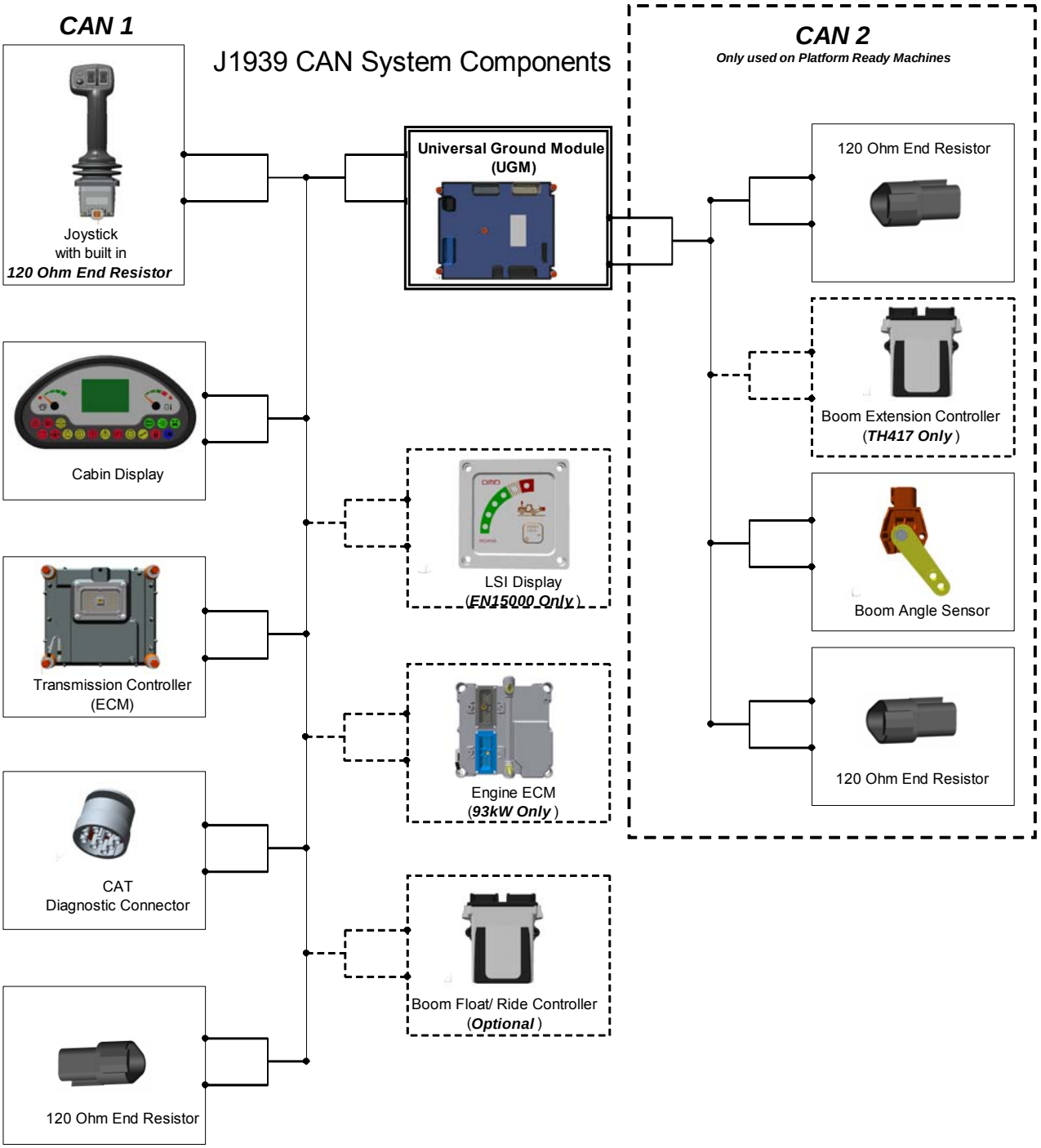

Figure 1 CAN bus component and control units' overview

Components and Control Units Locations on the machine

The following drawing shows component locations essential for troubleshooting.

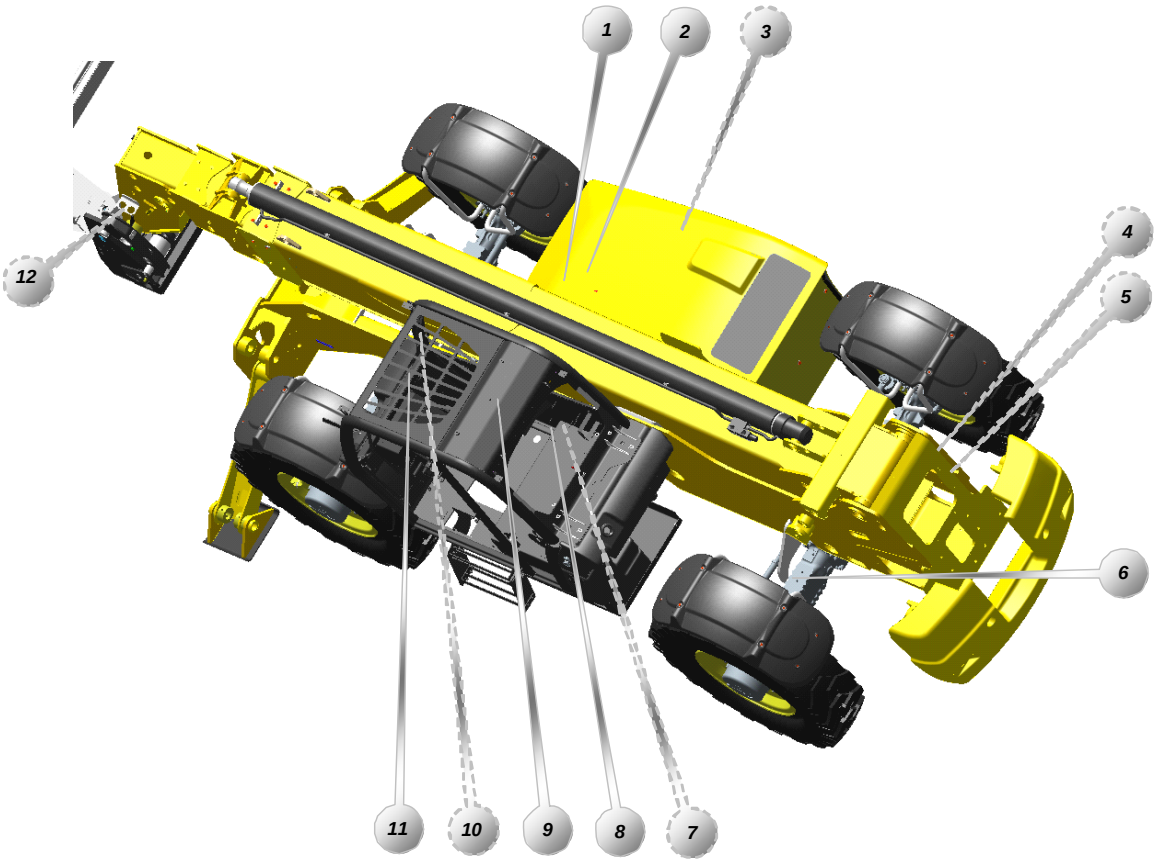

Figure 2 Locations

1. 120 Ω End Resistor CAN 1.
2. Transmission Controller (ECM).
3. Engine Controller (ECM).
4. 120Ω End Resistor CAN 2.(Platform)
5. Boom Angle Sensor (Platform)
6. LSI Sensor.
7. Optional Boom Ride/Float Controller or Boom Extension Limit Switch- TH417 Only.
8. Universal Ground Module (UGM).
9. Joystick with 120 Ω End Resistor CAN 1.
10. LSI Display (EN15000 Only).
11. Cabin Display.
12. 120Ω End Resistor CAN 2.(Platform)

Connector Locations and Pin Overview

The following table shows a connector and pin overview for electrical troubleshooting.

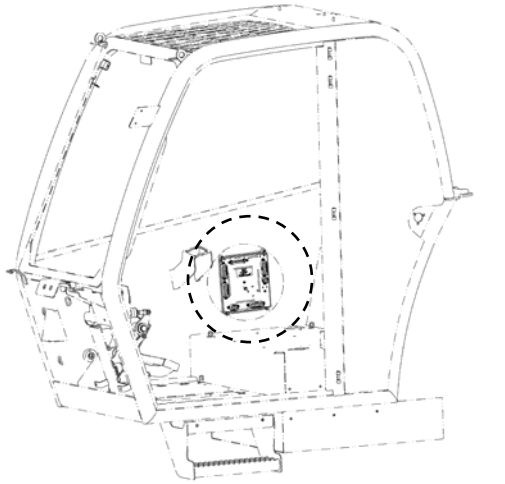

Illustration 1 UGM

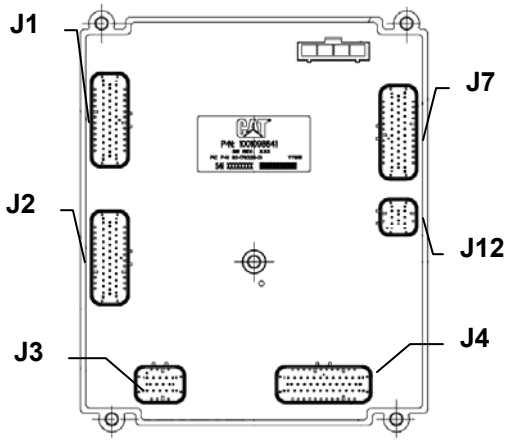

Illustration 2 UGM Connector Locations

The UGM and Power Distribution Board are located inside the cabin behind the right dash panels.

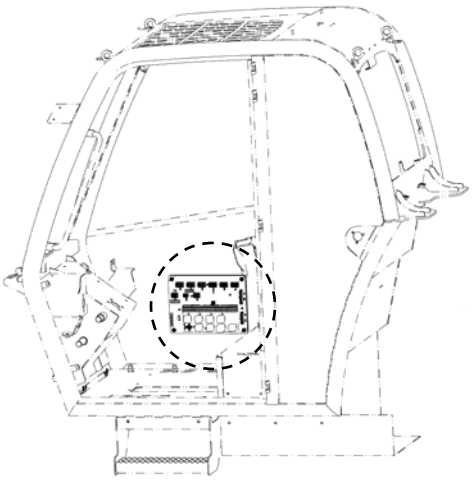

Illustration 3 Power Distribution Board

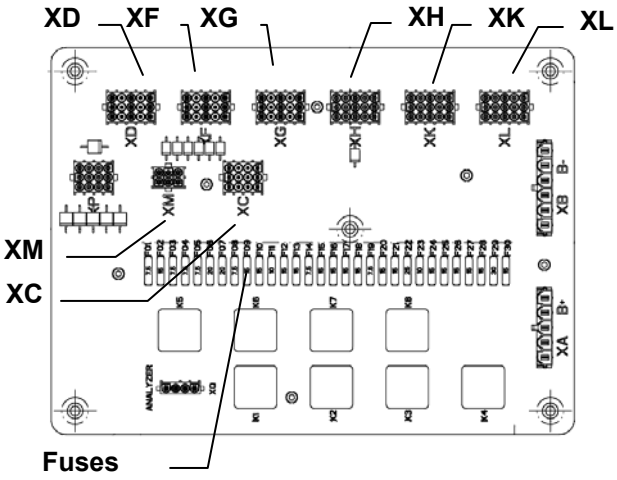

Illustration 4 Power distribution Board Connector Locations

Troubleshooting the CAN Bus:

Before you troubleshoot the components linked to the CAN Bus, perform a visual inspection of the machine and the installation itself. Specific checks and tests may be necessary in order to identify the root cause of any subsequent issues.

The failure of communication on the CAN bus can be caused by several sources:

- Failure of the CAN bus wiring inside the harness.
- Failure of one of the components or control units linked to the CAN bus.
- Failure of the voltage supply or ground to individual components or control units.
- Interference on the CAN bus wiring.
- Failure of the CAN bus terminating resistor.

Failure of the CAN Bus cables

The following faults can occur to the CAN bus wiring or harness

- CAN – High/Low open
- CAN – High/Low shorted to battery voltage
- CAN – High/Low shorted to ground or shield
- CAN – High shorted to CAN Low
- Loose or defective connector

Refer to 'Practical troubleshooting CAN Bus Signal – Channel 1 & 2' on page 10.

Failures on one or more components or control units linked to the CAN

Each component or control unit linked to the CAN has an integrated communication module that makes it possible for that component or control unit to exchange information on the CAN.

Failure of a component or control unit normally generates a diagnostic code in the UGM.

There are instances that a certain component or control unit can take down the entire CAN Bus. Code 6613 Excessive CAN bus errors will than be active in the UGM. In order to isolate the defective component or control unit, they have to be disconnected one at a time while monitoring the active codes in the UGM. If the defective component or control unit is disconnected and an active code is present regarding that component or control unit only, than this is the defective or interrupted component.

Failure of the voltage supply or ground to individual components or control units.

A slowly dropping battery voltage or a discharged battery can lead to sporadic CAN bus faults. The reason is that not all components or control units switch off communication at the same voltage level leaving other components or control units still trying to communicate.

Important: *Always verify a properly charged battery and charging system before beginning troubleshooting on the CAN.*

Interference in the CAN bus cables

Interference will have a similar effect to shorting or disturbing the CAN Bus wiring. Excessive interference can be created by moisture in the connections, a defective alternator or other devices such as a cell phone or amplifiers, this may induce the voltage into the CAN bus line and disrupt the communication. This type of interruption may be intermittent and are often difficult to reproduce.

Failure of a CAN bus resistor

Terminal resistors are used in the CAN bus circuit to establish the correct impedance to ensure fault free communication. Two 120 Ω resistors are installed at both ends of the CAN bus between CAN High and CAN low. Because the CAN bus circuit is a parallel circuit, the effective resistance of the complete circuit is 60 Ω. The resistors are there to prevent reflections of the data. A defective resistor could cause data communication errors.

Diagnostic Codes related to CAN bus.

Use the Practical Troubleshooting Procedures contained in this media if one of the below diagnostic codes relating to the CAN Bus Communication is present:

- 666. CAN Bus Failure – Engine Controller
- 6613. CAN Bus Failure – Excessive CAN Bus errors.
- 6616. CAN Bus Failure – Transmission Controller.
- 6617. CAN Bus Failure – Cabin Joystick.
- 6618. CAN Bus Failure – Cabin Display.
- 6621. CAN Bus Failure – Boom Angle Sensor.
- 6631. CAN Bus Failure – Boom Ride/Boom Float Module
- 6637. CAN Bus Failure – Boom Extension Limit Module
- 6638. CAN Bus Failure – LSI (EN15000 Only)

666. CAN Bus Failure – Engine Controller

When this diagnostic code occurs, the following responses will occur:

- Engine will not start.

Description: The ENGINE CONTROL menu is configured as ELECTRONIC and the UGM does not detect the ECM on the CAN bus.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the Pin/Contact table below.*

Resistance Measurements			
Measurement	**Engine Controller Contacts**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 20	J7 – 13 (UGM)	0 to 5 Ω
B	Contact 20	J7 – 24 (UGM)	54 to 66 Ω
C	Contact 21	J7 – 24 (UGM)	0 to 5 Ω
D	Contact 21	J7 – 13 (UGM)	54 to 66 Ω
E	Contact 40	XG – 7 (PDB)	0 to 5 Ω
F	Contact 2	XL – 15 (PDB) or GND	0 to 5 Ω

6613. CAN Bus Failure – Excessive CAN Bus errors

When this diagnostic code is present, the following responses will occur:

Description: The UGM detects more than 500 Bus Off or more than 500 Bus Passive conditions during a power cycle or the UGM detects more than 22 Bus Off or more than 22 Bus Passive conditions during a period of 1 second.

Troubleshoot: There are instances that a certain component or control unit can take down the entire CAN Bus. Code 6613 Excessive CAN bus errors will than be active in the UGM. In order to isolate the defective component or control unit, they have to be disconnected one at a time while monitoring the active codes in the UGM. If the defective component or control unit is

disconnected and an active code is present regarding that component or control unit only, than this is the defective or interrupted component.

6616. CAN Bus Failure – Transmission Controller

When this diagnostic code is present, the following responses will occur:

- Transmission stays in neutral.

Description: The UGM does not detect the TCM on the CAN bus when a POWERSYNCRO transmission is configured.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the Pin/Contact table below*

Resistance Measurements			
Measurement	**Contacts Transmission**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 64	J7-13 (UGM)	0 to 5 Ω
B	Contact 64	J7-24 (UGM)	54 to 66 Ω
C	Contact 65	J7-24 (UGM)	0 to 5 Ω
D	Contact 65	J7-13 (UGM)	54 to 66 Ω
E	Contact 3	XC Pin 3 (PDB)	0 to 5 Ω
F	Contact 2	XK Pin 11 (PDB)	0 to 5 Ω

6617. CAN Bus Failure – Cabin Joystick

When this diagnostic code is present, the following responses will occur:

- All Joystick Functions disabled.

Description: The UGM does not detect the cabin's joystick on the CAN bus for a period of 250msec.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the Pin/Contact table below.*

Resistance Measurements			
Measurement	**Contacts Joystick**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 3	J7-13 (UGM)	0 to 5 Ω
B	Contact 3	J7-24 (UGM)	54 to 66 Ω
C	Contact 4	J7-24 (UGM)	0 to 5 Ω
D	Contact 4	J7-13 (UGM)	54 to 66 Ω
E	Contact 1	XG Pin 8 (PDB)	0 to 5 Ω
F	Contact 2	XL Pin 15 (PDB)	0 to 5 Ω

6618. CAN Bus Failure – Cabin Display

When this diagnostic code is present, the following responses will occur:

- No information on Cabin Display.

Description: The UGM does not detect the cabin's display on the CAN bus.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the Pin/Contact table below.*

Resistance Measurements			
Measurement	**Contacts Cabin Display**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 9	J7-13 (UGM)	0 to 5 Ω
B	Contact 9	J7-24 (UGM)	54 to 66 Ω
C	Contact 14	J7-24 (UGM)	0 to 5 Ω
D	Contact 14	J7-13 (UGM)	54 to 66 Ω
E	Contact 5	XG Pin 5 (PDB)	0 to 5 Ω
F	Contact 12	XL Pin 15 (PDB)	0 to 5 Ω

6621. CAN Bus Failure – Boom Angle Sensor (*Platform Ready Only*)

When this diagnostic code is present, the following responses will occur:

- Display shows 99° angle value.
- Calibration boom angle sensor not allowed.
- No Lift Up function if platform is detected as attached or Platform Mode is Active.
- De-rate Max Lift Up speed.

Description: The UGM or platform module has lost communications with the Boom Angle Sensor.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 2 – page 14 - using the information as shown in the table below.*

Resistance Measurements			
Measurement	**Boom Angle Sensor Contacts**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 6	J12 – 3 (UGM)	0 to 5 Ω
B	Contact 6	J12 – 4 (UGM)	54 to 66 Ω
C	Contact 5	J12 – 4 (UGM)	0 to 5 Ω
D	Contact 5	J12 – 3 (UGM)	54 to 66 Ω
E	Contact 2	XC – 8 (PDB)	0 to 5 Ω
F	Contact 1	J1 – 18 or GND	0 to 5 Ω

6631. CAN Bus Failure – Boom Ride/ Boom Float Module

When this diagnostic code is present, the following responses will occur:

Description: The UGM has lost communications with the Boom Ride/Boom Float (Accessory) Module.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the information as shown in the table below.*

Resistance Measurements			
Measurement	**Contacts Boom Ride / Boom Float**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 9	J12 – 3 (UGM)	0 to 5 Ω
B	Contact 9	J12 – 4 (UGM)	54 to 66 Ω
C	Contact 10	J12 – 4 (UGM)	0 to 5 Ω
D	Contact 10	J12 – 3 (UGM)	54 to 66 Ω
E	Contact 1	XH Pin 3 (PDB)	0 to 5 Ω
F	Contact 2	XK Pin 13 (PDB)	0 to 5 Ω

6637. CAN Bus Failure – Boom Extension Limit Module

When this diagnostic code is present, the following responses will occur:

Description: The UGM has lost communications with the Accessory Module.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 2 – page 14 - using the information as shown in the table below.*

Resistance Measurements			
Measurement	**Contacts Boom Extension Limit (TH417)**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 9	J12 – 3 (UGM)	0 to 5 Ω
B	Contact 9	J12 – 4 (UGM)	54 to 66 Ω
C	Contact 10	J12 – 4 (UGM)	0 to 5 Ω
D	Contact 10	J12 – 3 (UGM)	54 to 66 Ω
E	Contact 1	XC Pin 12 (PDB)	0 to 5 Ω
F	Contact 2	J1- 18 (UGM)	0 to 5 Ω

6638. CAN Bus Failure – LSI

When this diagnostic code is present, the following responses will occur:

- Led G1 (Lowest Green LED), O5 (Orange LED) & R6 (Top Red LED) are Blinking.
- Alarm will sound.
- UGM recognize a overload condition, Hydraulic functions are in Cutout.

Description: The UGM has lost communications with the LSI system for 1000 milliseconds.

Troubleshoot: *Perform Troubleshooting CAN Bus channel 1 – page 12 - using the information as shown in the table below.*

Resistance Measurements			
Measurement	**LSI Display Contacts**	**UGM or PDB Contacts**	**Expected Result in Ω**
A	Contact 7	J7 – 13 (UGM)	0 to 5 Ω
B	Contact 7	J7 – 24 (UGM)	54 to 66 Ω
C	Contact 8	J7 – 24 (UGM)	0 to 5 Ω
D	Contact 8	J7 – 13 (UGM)	54 to 66 Ω
E	Contact 1	XG – 7 (PDB)	0 to 5 Ω
F	Contact 2	XL – 15 (PDB) or GND	0 to 5 Ω

Practical Troubleshooting CAN Bus Signal - Channel 1 & 2.

NOTE: Use the ***146-4080*** Digital Multimeter or an equivalent and two **7X-1710** Multimeter Probes or equivalents for the measurements in this procedure.

Test Step 1. TEST CAN HIGH- CHANNEL 1

A. Turn the key start switch to the ON position. Do NOT start the engine.

B. Locate the CAT diagnostic connector. To access, remove the screws securing the small side panel to the cab.

NOTE: On some units the harness for the ride control (optional) has to be disconnected from the CAT Diagnostic Connector.

C. Measure the voltage across the contact **G** and contact **B** (Machine ground).

Expected Result:

The voltage that is measured is approximately between 3.5DCV and 4.5 DCV.

Repair:

If the voltage measured on CAN High is approximately 12 DCV than most likely CAN High is shorted to battery – Repair or replace harness

If the voltage measured is 0 DCV than most likely CAN High has an open wire or is shorted to ground. Repair or replace the harness.

Test Step 2. TEST CAN LOW - CHANNEL 1

D. Leave the key start switch to the ON position.

E. Measure the voltage across the contact **F** and contact **B** (Machine ground) on the CAT Diagnostic Connector

Expected Result:

The voltage that is measured is approximately between 0.5DCV and 1.5 DCV.

Repair:

If the voltage measured on CAN Low is approximately 12 DCV than most likely CAN Low is shorted to battery – Repair or replace harness

If the voltage measured is 0 DCV than most likely CAN Low has an open wire or is shorted to ground. Repair or replace the harness.

Test Step 3. TEST CAN HIGH- CHANNEL 2

NOTE: Step 3 & 4 should be only applied if you have a TH414, 514 or 417 that is platform ready.

F. Leave the key start switch to the ON position.

G. Locate the Boom Angle Sensor at the rear of the frame. This can be accessed through the rear of the frame.

H. At the back of the harness connector for the sensor, insert a **7X-1710 Multimeter Probe** or an equivalent along the CAN High wire (contact 6) and another **7X-1710 Multimeter Probe** or an equivalent along the ground wire (contact 1).

I. Measure the voltage across the contact **6** and contact **1** (Machine ground)

Expected Result:

The voltage that is measured is approximately between 3.5DCV and 4.5 DCV.

Repair:

If the voltage measured on CAN High is approximately 12 DCV than most likely CAN High is shorted to battery – Repair or replace harness

If the voltage measured is 0 DCV than most likely CAN High has an open wire or is shorted to ground. Repair or replace the harness.

Test Step 2. TEST CAN LOW - CHANNEL 2

J. Leave the key start switch to the ON position. Do NOT start the engine.

K. At the back of the harness connector for the sensor, insert a **7X-1710 Multimeter Probe** or an equivalent along the CAN Low wire (contact 5) and another **7X-1710 Multimeter Probe** or an equivalent along the ground wire (contact 1).

L. Measure the voltage across the contact **5** and contact **1** (Machine ground)

Expected Result:

The voltage that is measured is approximately between 0.5DCV and 1.5 DCV.

Repair:

If the voltage measured on CAN Low is approximately 12 DCV than most likely CAN Low is shorted to battery – Repair or replace harness

If the voltage measured is 0 DCV than most likely CAN Low has an open wire or is shorted to ground. Repair or replace the harness.

Practical Troubleshooting CAN Bus Components on Channel 1

NOTE: Use the ***146-4080*** Digital Multimeter or an equivalent for the measurements in this procedure.

NOTE: The following test procedures may create other diagnostic codes. Ignore these created diagnostic codes.

Test Step 1. TEST THE HARNESS.

A. Turn the main disconnect switch to the OFF position.
B. Inspect all harness connections that are related to the CAN bus – *refer to page 3*. Make sure that connectors are clean and tight.
C. Check the connectors for proper mating, ensure that all the seals are present and in place.
D. Check the harness for signs of damage or abrasion.
E. Check the wires at the connector. Ensure that the wires are secured tightly into the connector.
F. Check the exposed wires at the connectors for nicks or signs of abrasion.
G. Check for moisture inside the connector.
H. Check the connector for dirty contacts or corroded contacts.
I. Check each pin and each socket of the machine harness connector. Ensure that the contacts are properly installed. The contacts should mate correctly when the two pieces of the connector are place together.
J. Disconnect the connector(s) of :
    a. Of the *component* or *control Unit* related to the active code.
    b. **J7** of the *UGM*
    c. *Power Distribution Board* (PDB) as per table.
K. Measure the resistance from the following contacts that are provided in the table.

Note: Refer to page 3 for the location of the components.

Expected Result:
The resistance values agree with the table.

Result:
OK- The resistance values agree with the table. Proceed to Test Step 4

NOT OK – Any of the measurements A, C, E, or F does not agree with the table.

Repair:
Repair or replace the harness

NOT OK- Any of the measurements B or D does not agree with the table. Proceed with Test Step 2.

Test Step 2. CHECK THE TERMINATION RESISTORS.

A. De-energize the system.

B. Disconnect the **JS75** connector from the *Joystick* inside the cabin and measure the resistance across pin 3 and pin 4 on the *Joystick*. Note the resistance.

C. Disconnect the connection **X155** inside the engine compartment, close to the transmission controller and measure the resistance across **pin 1** and **pin 2**. Note the resistance.

Expected result:

The resistances measured are **120 ± 12 Ω**.

Repair:

Replace the Joystick or the termination resistor(s) that did not measure **120 ± 12 Ω**.

Test Step 3. CHECK THE INPUT VOLTAGE.

M. Reconnect all connectors except the connector to the *component* or *control unit.*

N. Turn the key start switch to the ON position. Do NOT start the engine.

O. Measure the voltage across the contacts mentioned in **row E & F** of the table.

Expected Result:

The voltage that is measured is approximately 12 DCV.

Repair:

If the voltage measured is approximately 12 DCV than most likely the component or control unit has failed.

If the voltage measured is 0 DCV or significant below 10.5 DCV. The *PDB* may have failed or the *component or control unit* does not get the required battery voltage. Proceed to Test Step 4.

Test Step 4. CHECK THE BATTERY VOLTAGE TO THE POWER DISTRIBUTION BOARD.

A. Reconnect all harness connectors.

B. Turn the key start switch to the ON position, but do NOT start the engine

C. Use a spoon to measure the battery voltage on the PDB between the contact mentioned in **row E** (see table) and machine ground.

Expected result:

The voltage that is measured is approximately 12 DCV.

Repair:

If the voltage measured is 0 DCV a Fuse might blown or the voltage measured is significant below 12 DCV there might be an issue with the charging system. Check battery first.

Practical Troubleshooting CAN Bus Components on Channel 2

Test Step 1. TEST THE HARNESS.

A. Turn the main disconnect switch to the OFF position.
B. Inspect all harness connections that are related to the CAN bus. Make sure that connectors are clean and tight.
C. Check the connectors for proper mating, Ensure that all the seals are present and in place.
D. Check the harness for signs of damage or abrasion.
E. Check the wires at the connector. Ensure that the wires are secured tightly into the connector.
F. Check the exposed wires at the connectors for nicks or signs of abrasion.
G. Check for moisture inside the connector.
H. Check the connector for dirty contacts or corroded contacts.
I. Check each pin and each socket of the machine harness connector. Ensure that the contacts are properly installed. The contacts should mate correctly when the two pieces of the connector are place together.
J. Disconnect the connector(s) of :
    a. Of the *component* or *control Unit* related to the active code.
    b. **J12** of the *UGM*
    c. *Power Distribution Board* (PDB) or *UGM* as per table.
K. Measure the resistance from the following contacts that are provided in the table.

Note: Refer to page 3 for the location of the components and connectors.

Expected Result:
The resistance values agree with the table.

Result:
OK- The resistance values agree with the table. Proceed to Test Step 4

NOT OK – Any of the measurements A, C, E, or F does not agree with the table.

Repair:
Repair or replace the harness.

NOT OK- Any of the measurements B or D does not agree with the table. Proceed with Test Step 2.

Test Step 2. CHECK THE TERMINATION RESISTORS.

A. De-energize the system.

B. Disconnect the **X34** connector under the cabin and measure the resistance across **pin 14** and **pin 15**. Note the resistance.

C. Disconnect the connector **X201** at the boom head and measure the resistance across **pin T** and **pin U**. Note the resistance.

Expected result:

The resistances measured are **120 ± 12 Ω.**

Repair:

Replace the termination resistor(s) that did not measure **120 ± 12 Ω**

Test Step 3. CHECK THE INPUT VOLTAGE

A. Reconnect all connectors except the connector to the *component* or *control unit*

B. Turn the key start switch to the ON position. Do NOT start the engine.

C. Measure the voltage across the contacts mentioned in **row E & F** of the table.

Expected Result:

The voltage that is measured is approximately 12 DCV.

Repair:

If the voltage measured is approximately 12 DCV than most likely the component or control unit has failed.

If the voltage measured is 0 DCV or significant below 12 DCV. The PDB may have failed or the BOOM ANGLE Sensor does not get the required battery voltage. Proceed to Test Step 4.

Test Step 4. CHECK THE BATTERY VOLTAGE TO THE POWER DISTRIBUTION BOARD.

A. Reconnect all harness connectors.

B. Turn the key start switch to the ON position, but do NOT start the engine

C. Use a spoon to measure the battery voltage on the PDB between the contact mentioned in **row E** (see table) and machine ground.

Expected result:

The voltage that is measured is approximately 12 DCV.

Repair:

If the voltage measured is 0 DCV or significant below 12 DCV. The PDB may have a blown fuse 09 or there might be an issue with the charging system.