COMMUNICATION WITH UNFAMILIAR OFF-ROAD VEHICLE CONTROLLER AREA NETWORK (CAN) SYSTEMS IN THE FIELD

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To the funders

- Many thanks to those who made developing this procedure something worth doing…

CALIFORNIA AIR RESOURCES BOARD

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

San Joaquin Valley APCD

Outline of Presentation

- The need for the method
- The tool set
  - Mechanical/Electrical
  - Data form
- Finding the connector
- Interfacing logger to connector
- Finishing the installation

The Trend – and Issue

- Recent emphasis on off-road data collection
  - Earth movers (construction site, agricultural, etc.)
  - Material handling (building, warehousing, etc.)
  - Goods transport (ports, transfer yards, etc.)
- No standardized “OBD”
  - Make/model-specific connectors
  - Make/model-specific connector locations

Bias in the Activity Sample?

- Off-road is mainly professional
  - Time really IS money
  - Incompatibility with telematics systems
    - downtime… anger, diagnostic, repair
  - Safety & Security
- Smaller firms have fewer resources to spare
  - “Dealing with you means I’m not dealing with my business.”
- Participating firms tend toward the larger, politically active/connected
  - Representative??

Flexible Tool Set

Data Form

Template for CAN pinout assessment

Connector:
Make:
Displacement:
Emission Year:

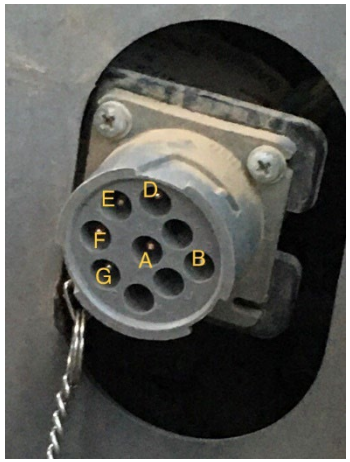
1st ☐ Sketch pin pattern and number pins, if necessary
Note orientation keys and unpopulated pins/sockets
2nd ☐ If necessary, change BLUE pin/socket IDs (1st column) on table below
Key-off. Master power on.
3rd ☐ Find best chassis ground pin — Chassis pin: ?
4th ☐ See if "unswitched" power is available — Power pin: ?
5th ☐ Record "key-on" voltages in table (to the 1st decimal)
6th ☐ Turn off Master Power Switch and record resistances (no decimal).

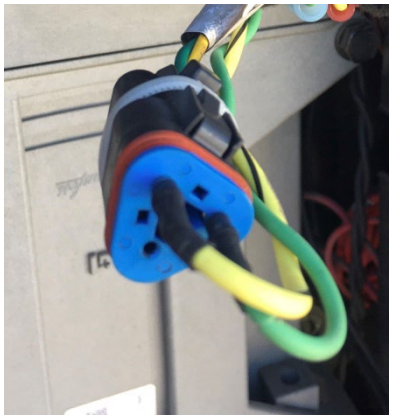
CAN high pin: ?
CAN low pin: ?

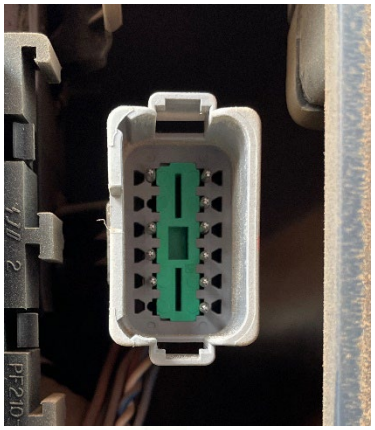
NOTES:

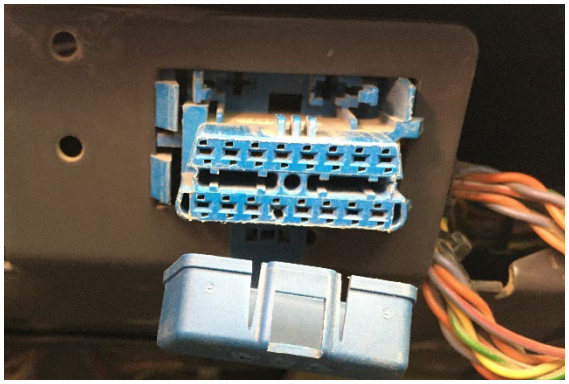
	Chassis	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	V														
	Ω	1													
2	V	V													
	Ω	Ω	2												
3	V	V	V												
	Ω	Ω	Ω	3											
4	V	V	V	V											
	Ω	Ω	Ω	Ω	4										
5	V	V	V	V	V										
	Ω	Ω	Ω	Ω	Ω	5									
6	V	V	V	V	V	V									
	Ω	Ω	Ω	Ω	Ω	Ω	6								
7	V	V	V	V	V	V	V								
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	7							
8	V	V	V	V	V	V	V	V							
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	8						
9	V	V	V	V	V	V	V	V	V						
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	9					
10	V	V	V	V	V	V	V	V	V	V					
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	10				
11	V	V	V	V	V	V	V	V	V	V	V				
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	11			
12	V	V	V	V	V	V	V	V	V	V	V	V			
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	12		
13	V	V	V	V	V	V	V	V	V	V	V	V	V		
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	13	
14	V	V	V	V	V	V	V	V	V	V	V	V	V	V	
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	14
15	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω

Off Road CAN Connector Examples





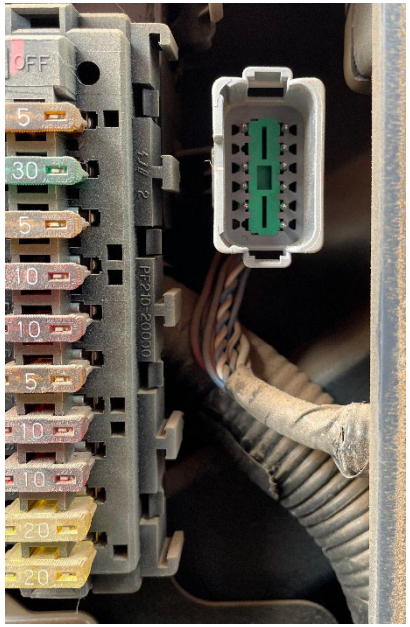




Equipment Examples

Finding the CAN Connector

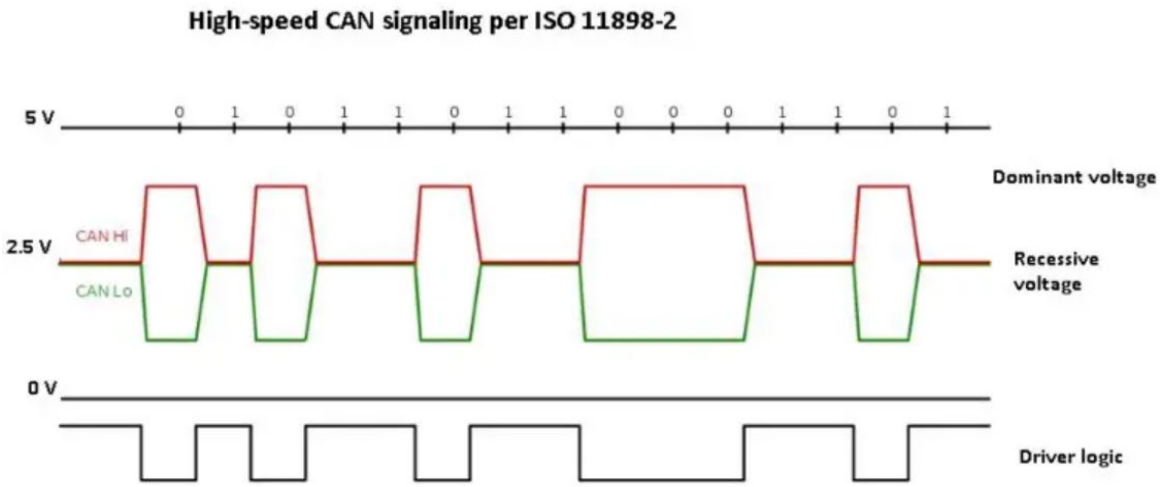
- Look for the fuse panel(s) first!

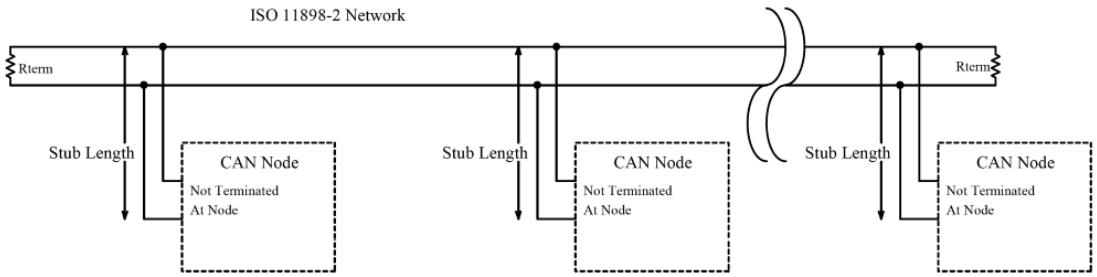


The Physical Side of CAN

from: https://www.testandmeasurementtips.com/exploring-canbus-oscilloscope/

The two signal lines, when passively biased, measure 2.5 V.
When the CANH line becomes dominant, the voltage increases to 3.5 V, and the CANL line drops to 1.2 V, so there is a 2-V differential signal.





Finding CAN Signals

Notes on finding CAN network

Source: DG Technologies Product Pinouts and Industry Connectors Reference Guide

Test resistance with battery disconnected (via master switch or disconnected positive at battery).
Battery connected might give wrong readings.

CAN-hi to CAN-lo: 60 Ω (+/- 10%)
This is due to two, 120 Ohm resistors in parallel at the two logical ends of the network.
Lower values (44 Ohms or less) probably means additional resistors on retrofit components, like drivers logs, loggers, etc. Could also mean a short between CAN--hi and CAN-lo conductors.
Higher values (120 Ohms or more) probably means bad connection to one or both terminating resistors.

CAN-hi/CAN-lo to chassis/ground: ≥ 10 kΩ
This is for isolation between ground and network. Less indicates a short to ground/chassis.

From experience and J1939 specification...
Test voltage with key-on.

CAN-hi to chassis/ground: from 2.5 Vdc to 3.5 Vdc typical.
CAN-lo to chassis/ground: from 0.5 Vdc to 2.5 Vdc typical, as long as CAN-hi - CAN-lo = 2 to 2.5 Vdc.
I often seen CAN-hi at 2.5 Vdc and CAN-lo at 2.4 Vdc from chassis.

The signal on the can wires is square wave, mirror images (opposed). During bit=0, the difference between CAN-hi and CAN-lo is 2 - 2.5 Vdc. During bit=1 the difference is 0 V.

Which Pins/Sockets?

Connector: 12-pin deutsch type rectangular
Engine Make: Komatsu
Displacement: 8.9 L
Emission Year: 2016 label

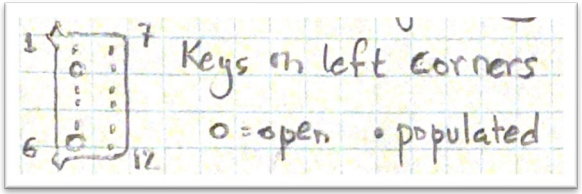
	Chassis											
1	0 V											
	2 Ω	**1**										
	V	V										
	Ω	Ω										
3	2.4 V	2.4 V	V									
	∞ Ω	∞ Ω	Ω	**3**								
4	0 V	0 V	V	2.4 V								
	0 Ω	1.2 Ω	Ω	19 MΩ	**4**							
5	2.2 V	2.2 V	V	V	2.2 V							
	∞ Ω	∞ Ω	Ω	∞ Ω	∞ Ω	**5**						
	V	V	V	V	V	V						
	Ω	Ω	Ω	Ω	Ω	Ω						
7	25 V	25 V	V	V	25 V	V	V	<= unswitched				
	∞ Ω	∞ Ω	Ω	∞ Ω	34 MΩ	∞ Ω	Ω	**7**				
8	25 V	25 V	V	V	25 V	V	V	V	<= switched			
	1.2 kΩ	1.2 kΩ	Ω	3 MΩ	1 kΩ	20 MΩ	Ω	Ω	**8**			
9	2.5 V	2.5 V	V	100 mV	2.5 V	V	V	V	V	variable 90 - 180 mV		
	∞ Ω	∞ Ω	Ω	60 Ω	∞ Ω	∞ Ω	Ω	Ω	Ω	**9**		
10	0 V	0 V	V	V	V	V	V	V	V	V		
	5.7 MΩ	5.7 MΩ	Ω	32 MΩ	5.3 MΩ	33 MΩ	Ω	6.3 MΩ	65 kΩ	25 MΩ	**10**	
11	2.5 V	2.5 V	V	V	2.5 V	257 mV	V	V	V	V	V	
	∞ Ω	∞ Ω	Ω	∞ Ω	∞ Ω	60 Ω	Ω	∞ Ω	∞ Ω	∞ Ω	∞ Ω	**11**
12	24 V	24 V	V	V	24 V	V	V	V	V	V	V	V
	∞ Ω	∞ Ω	Ω	∞ Ω	∞ Ω	∞ Ω	Ω	∞ Ω	∞ Ω	∞ Ω	∞ Ω	∞ Ω
	V	V	V	V	V	V	V	V	V	V	V	V
	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω

<= unswitched

1st	X	Sketch pin pattern and number pins, if necessary
		Note orientation keys and unpopulated pins/sockets
2nd	X	If necessary, change BLUE pin/socket IDs (1st column) on table below
3rd	X	Find chassis ground pin
4th	X	Record "key-on" voltages in table (esp. rel. to chassis)
		If battery voltage, check also with "key-off" to see if "unswitched"
6th	X	Turn off Master (battery) Power Switch and record resistances

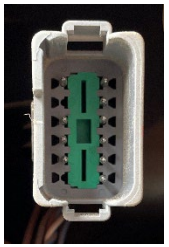
Chassis pin: 4
Power pin: 7
CAN high pin: 9
CAN low pin: 3

NOTES:



Chassis pin also at pin 1
Unswitched power also at pin 12

CAN also available on 5 & 11, but no parameters recognized from J1939 master db.



Interfacing with Logger

- Record All Data for a minute or two
  - Key-on. Start engine, if possible.
- Compare to master J1939 database
- Instruct logger which messages to record

Finish Installation

Q? ➔ A!

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