Automotive Communication Systems

1

Goals

- At the completion of this program the attendee will:
- Be able to describe the purpose of the communication systems
- Identify communication types
- Describe the most common types of automotive communication systems
- Identify and describe the operation of the circuit physical components
- Identify proper message signals for the most common communication types
- Create a diagnostic plan for system faults
- Correctly identify possible causes of incorrect communications
- Quickly and accurately diagnose and repair communication faults

2

Purpose

- With the addition of control modules, a communication bus was required to allow modules to communicate with one another
- They also began to communicate with scan tools
- Modules then became sophisticated enough where they could be programmed through a hardwired communication BUS
- The more modules that were added to vehicles required a robust network to allow all of these modules to communicate with one another
- The tighter emissions standards became, the quicker the processing speeds in the modules needed to become to make very fast adjustments
- Safety systems began to be added such as ABS, Supplemental Restraint Systems and ADAS which requires messages to be shared and decisions to be made in almost real time, driving the need for a more robust, faster communication system

3

History

- Tightening vehicle emission standards drove the need for a computer
- In order to control the fuel and spark systems a computer was used to monitor the engines emission outputs and make corrections to the fuel and spark to lower the exhaust emissions
- A PROM, programmed read only memory chip was installed which contained a basic set of operating parameters for the engine
- A sensor was used to monitor the exhaust emissions then adjustments could be made by preset parameters in the PROM
- The early systems did not provide any way to update the software in the module
- Eventually, the PROM became removeable and could be replaced with different units to change operating parameters
- Then the PROM could be electronically erased and a new software set installed allowing for the reuse of the hardware component

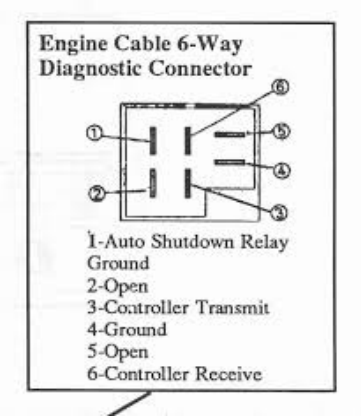
4

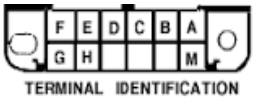
History

- First systems were used with carburetors
- Very slow, maybe 7kbps
- Did not communicate with any other modules
- Limited if any scan tool communication, first systems used flash code technology to share trouble codes
- Once fuel injection was introduced, the processor speeds increased and tools were allowed to begin to communicate with the control module
- Most manufacturers by 1988 had widely accepted fuel injection and developed scan tools and communication protocols that allowed information to be shared between the control module and the scan tool
- The data the computer was seeing, and the adjustments it was making could now be viewed on a handheld electronic device
- In 1996 there was an introduction of a standard for vehicle communication systems (OBDII)

5

OBD 1 Connectors





A	GROUND	F	T.C.C. (IF USED)
B	DIAGNOSTIC TERMINAL	G	FUEL PUMP (IF USED)
C	A.I.R. (IF USED)	H	BRAKE SENSE SPEED INPUT (CK)
D	SERVICE ENGINE SOON LAMP (IF USED)	M	SERIAL DATA (L4) (SEE SPECIAL TOOLS)
E	SERIAL DATA (SEE SPECIAL TOOLS)		

6

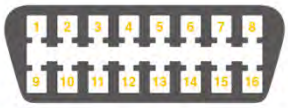
History

- OBDII provided a means to standardize communication in vehicles
- A standard interface connector was introduced for scan tool connection points the SAE J1962 connector
- The J1962 connector provides an access point for:
- Battery power
- Chassis ground
- Signal ground
- Multiple communication protocols
- Module programming access

7

J1962 Connector

- The J1962 standard provided a common architecture for all manufacturers
- 3 PINS will ALWAYS be the same no matter what communication system is used:
- Pin 4 Chassis Ground
- Pin 5 Signal ground (ECM)
- Pin 16 Battery voltage



PIN	DESCRIPTION	PIN	DESCRIPTION
1	Vendor Option	9	Vendor Option
2	J1850 Bus +	10	j1850 Bus
3	Vendor Option	11	Vendor Option
4	Chassis Ground	12	Chassis Ground
5	Signal Ground	13	Signal Ground
6	CAN (J-2234) High	14	CAN (J-2234) Low
7	ISO 9141-2 K-Line	15	ISO 9141-2 Low
8	Vendor Option	16	Battery Power

OBD-II Connector and Pinout

8

Communication Types

- Several communication types are used in modern vehicles:
- Some common communication protocols are:
- J1850 single or dual wire
- K-Line
- CAN BUS
- LIN
- Ethernet
- Flex-CAN
- Flexray
- SENT

9

Bits, Bytes, Messages

- Computers “Talk” in binary language
- The language spoken is 1s and 0s
- A single bit is one 0 or 1
- A bit can be created either by switching a voltage high or low, or a time has passed
- 8 bits create a byte
- The organization of the bits in the byte will create a data stream
- IE may: 11001100=h or 00110011=x or so on these are hexadecimal bits
- Then the hexadecimal data can be put together to create messages IE: hx01

10

Creating Messages

- A bit can be created by pulling a voltage high
- A bit can be created by pulling a voltage low
- A bit can be created if a set time has passed even if a change in voltage is not performed
- 0-5 volts could create a 1 or 0
- 5-0 volts could create a 1 or 0
- A measure of time can be assigned as a bit IE: 20us=1 regardless of voltage change
- So 20us without a voltage change would be a 1 40us without a change would be 11
- Using time to create bits is typically VPW variable pulse width
- Using voltage to create bits is PWM pulse width modulation

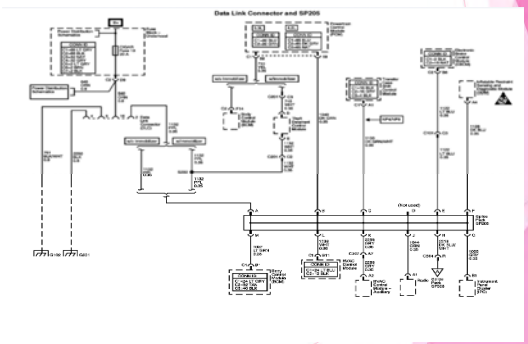
11

Early Systems

GM

- Class 2 Data
- A slow single wire bus used to transmit messages across modules
- May be a private bus
- 0-7 volts remains high at rest and pulled low to talk
- Messages sent as streams not packets, not clocked to a module timer
- One module in control of sending message using a set of bits to indicate message start and data
- All modules receive this message only ones that need it accept the data

GM Class 2 Bus



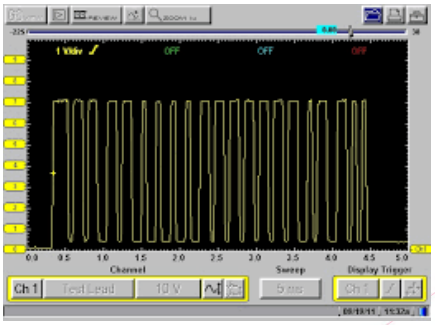
12

Early Systems

GM

- Began in the early 90s
- Class 2 data
- PIN 2 of the DLC
- Single wire BUS
- J1850 VPW
- Bit time indicates the binary data, not voltage switches
- For example, a 20us bit would indicate a 1
- A 40us high could indicate a 0
- 10.4kbs
- 0-7 volts, o volts at rest pulled high to 7 volts to talk
- Allowed for scan tool data and eventually communication between modules
- Star type configuration

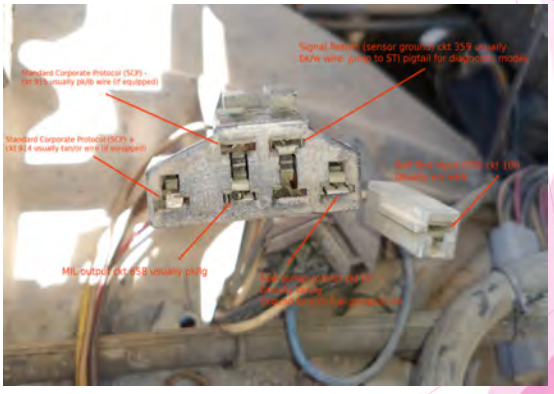
J1850 VPW



13

Early Ford

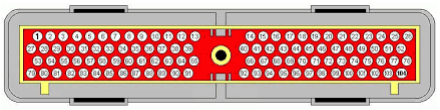
- EEC IV first system to offer scan tool communication
- Introduced in 1983
- Scan tool communication started around 1987
- Single wire 9.6kps
- Typically around 5 volts
- May have some communication abilities early units used flash codes



14

Early Ford

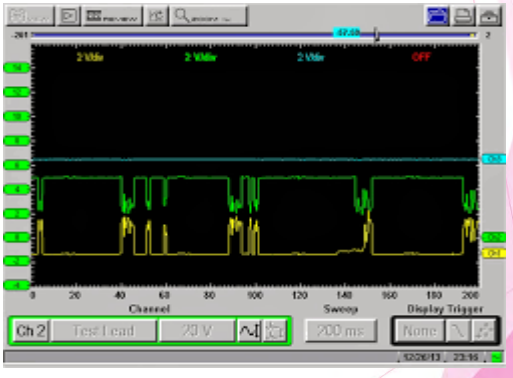
- EEC V
- Better data and speed but not great
- 18kbps
- Single wire 10 volt circuit
- Pre-OBD 2 but was still used after 1996
- PCM typically has 104 pins
- Has Bidirectional and data capabilities
- May be able to flash program



15

Early Ford SCP

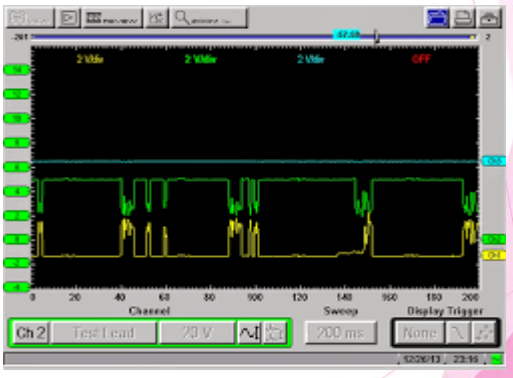
- Standard Corporate Protocol (SCP)
- Used in OBD-II systems
- 5 volt differential bus
- 41.6 kbps
- Allowed for programming
- Signals mirror each other
- 0-5 volts
- SCP + 0 volts gets pulled high to talk
- SCP- 5 volts gets pulled low to talk
- Uses terminating resistors
- May still work if one communication line breaks, shorted to ground or voltage or if some of the terminating resistance is lost



16

Early Ford SCP

- Both signals must be the same
- There is some fault tolerance for the loss of one signal but communication can fail if the voltage differential is not available
- J1850 PWM protocol
- Pins 2 and 10 in the DLC



17

Chrysler

- Early systems were CCD Chrysler Collision Detection
- CCD indicates a multiplexed BUS can send coded messages that will avoid message collisions by assigning IDs to messages
- 2 wire CCD + and CCD –
- A series of resistors create bus voltage bias that travels through the circuit to a terminating resistor

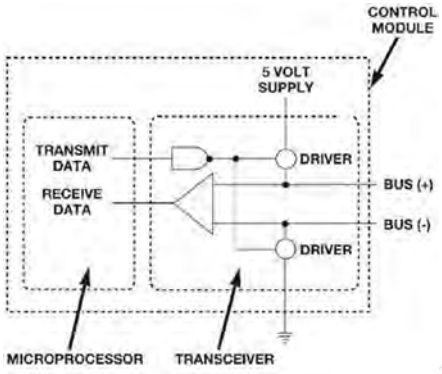


Fig. 5 CCD Chip

18

Chrylser

- Bias voltage on bus – is 2.51 v
- Bias voltage on bus + is 2.49 volts
- This creates a .020 difference between BUS + and –
- To talk the negative bus will increase voltage to around 100 mv it can go as high as 125 mv
- An increase in voltage on the negative side creates a 0 bit
- Two wire J1850 PWM

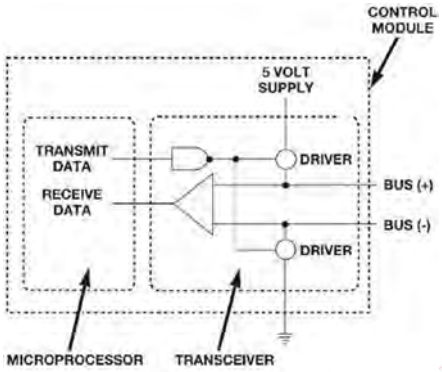


Fig. 5 CCD Chip

19

J1850

- Single wire systems use variable time messages that can switch high to low or low to high
- Single wire speeds typically 10.1kbps
- The bit can be recessive at a low voltage or a high voltage
- The bit will become dominant to talk and be pulled the opposite way from recessive
- A clock is not used, but timing of the bits is monitored and can indicate the part of the message that is being broadcast
- For example, if a bit remains static or changes state for 64us that would indicate a 1
- A SOF frame message would be pulled dominate for a set period of time indicating the SOF

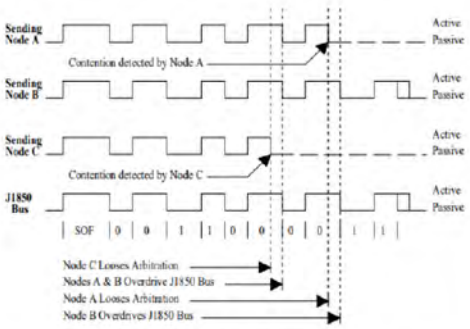


Figure 2. Bit-by-bit Arbitration

20

J1850 Single Wire (PIN 2)

- The module is not necessarily concerned with the change of state, rather how long it remains at a given state
- Since many messages can travel on the same bus for many modules there has to be a way to prioritize these messages
- For example, an airbag crash signal would take arbitration over an engine coolant temperature sensor sent to the BCM form the ECM, to apply arbitration, the EOF message that sends a bit for the longest time will win the arbitration

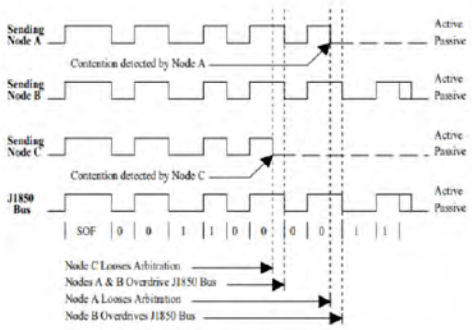
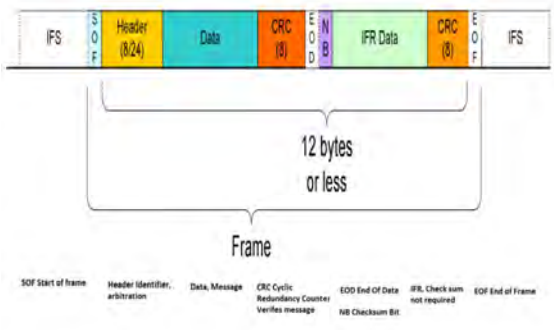


Figure 2. Bit-by-bit Arbitration

21

Message Construction J1850 PWM

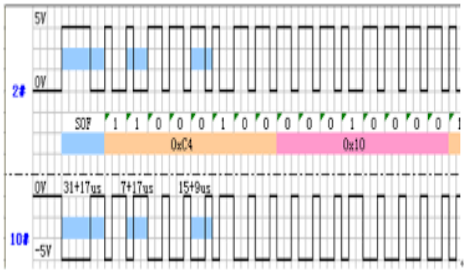
- SOF start of frame is 200us high potential + pulled off ground and – pulled towards ground
- The header (message ID) can be 8024 bits and indicates what module and the arbitration of the message
- The data is the message
- CRC is a cyclic redundancy counter that verifies message is “understandable”
- EOD end of the data
- NB check BIT indicates message verification
- IFR data is not necessary but can include additional verification information
- 8 bit CRC then the EOF end of frame (message) indicates the completion of this message



22

J1850 Two Wire (PINS 2,10)

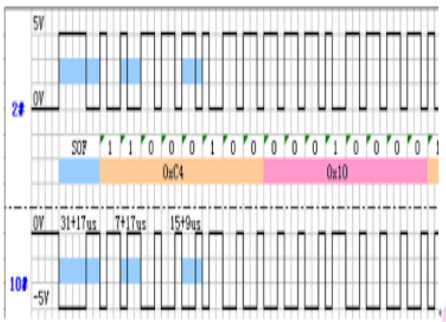
- If a J1850 bus incorporates two wires it becomes more redundant
- The additional wire indicates a mirror message of the first message, using a voltage differential
- Communicates at a faster speed, 41kbps
- Voltages on PINs 2 and 10 mirror each other with a voltage differential between the two
- the voltage differential is measured as a single data



23

J1850 PWM

- Normally there is about .010 volts difference of both + and – at rest (recessive)
- When + goes high and – is pulled low the voltage difference is typically around .100 volts to .125 volts
- So 10mv is considered recessive and 100mv is considered dominant
- Each bit is assigned a time
- So if the time for each bit is known, it can be monitored how many bits are in a given amount of time



24

J1850

- Can be designed as a single or dual wire setup
- Some manufactures used a similar type under other trade names
- Serial Corporate Protocol (Ford)
- Class 2 DATA (GM)
- Chrysler Collision Detection (CCD)
- VPW is single wire
- PWM is dual wire voltage
- Pin 2 is used for both types
- If 2 wire PWM then pin 10 is also used as a low signal

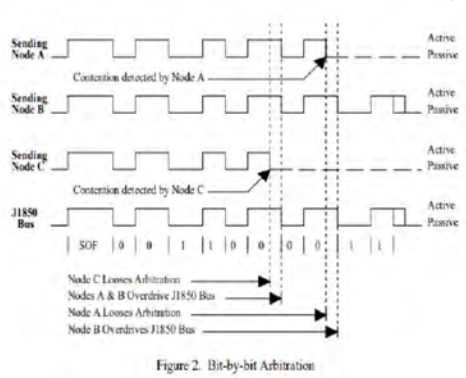
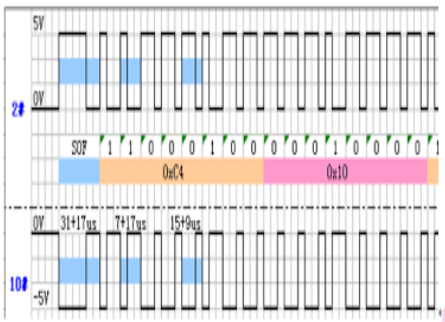


Figure 2. Bit-by-bit Arbitration

25

J1850 PWM

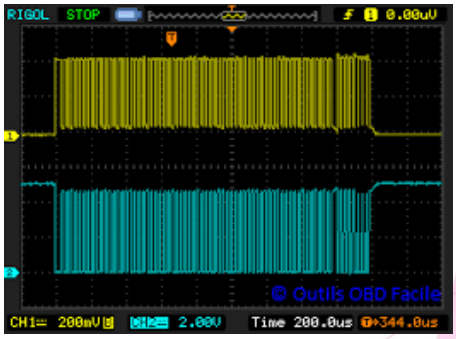
- Each bit is assigned a time
- So if the time for each bit is known, it can be monitored how many bits are in a given amount of time
- If a single bit is 20us and 40us were to pass with the voltage potential remaining high (dominant) then that would indicate two 1 bits
- If 80us were to pass and the voltage remained high, that would indicate four 1 bits



26

J1850 PWM 2 Wire

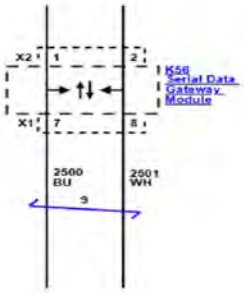
- Unlike the J1850 single wire VPW the 2 wire system is PWM
- A change in voltage state indicates bits, rather than the change in length of the change indicating bits, like the VPW system
- So a PWM 2 wire system compares the voltages between J1850 Pin 2 (+Voltage) and Pin 10 (- Voltage)
- Mirror messages are on each terminal, the voltage difference between the 2 will indicate if the bus is dominant or recessive



27

Physical Layer Wiring

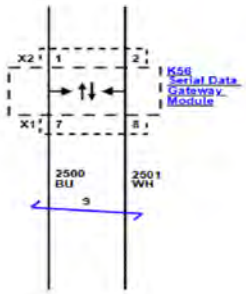
- Two wire systems are often wrapped around each other
- Wrapping a high and low voltage wire around each other will help prevent electromagnetic interference (EMI) from entering the message wiring
- Most OEs will provide a number of wraps in a distance that the twists should be placed at
- In the example to the right, the wires should receive 9 wraps per foot and should be twisted clockwise towards the SGM
- Module design can also be used to defer EMI



28

Physical Layer Wiring

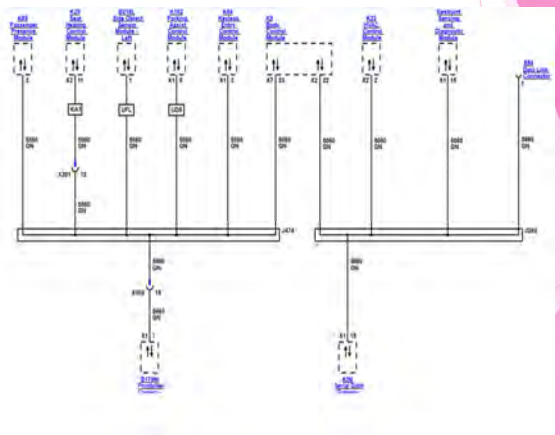
- Any wiring repair should be placed in the same area as the damaged wiring
- The replacement wiring should be the same length as the wires removed
- Same gauge wire should be used to allow for correct wraps
- Connections should be soldered and sealant heat shrink applied
- To wrap replacement wires, place 2 wire ends in a vice, put the other 2 ends in a drill and slowly run the drill. Measure the WPF and the length



29

Physical Layer

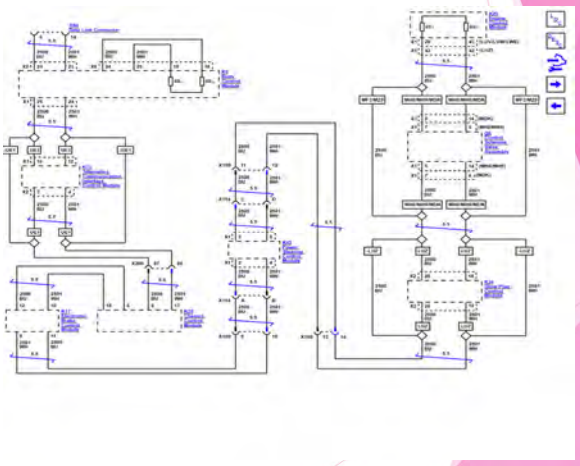
- There are typically three types of communication bus wiring
- Star: a central connection point exists for all of the module communication lines
- Typically used in single wire systems like VPW J1850
- Can be easier to diagnose communication faults having a point to test modules individually



30

Physical Layer

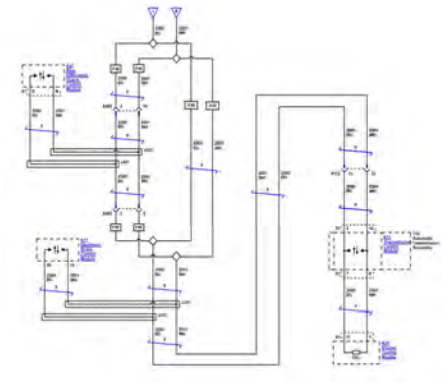
- Two wire busses commonly will use a ring architecture
- All messages pas through all modules
- An open in one module will prevent communication with some or all modules
- End modules typically have the terminating resistors in them



31

Physical layer

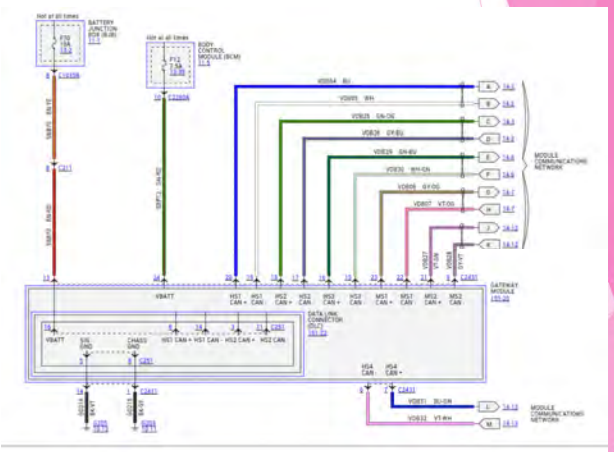
- Hybrid of ring and star
- Incorporates both types of wiring
- Some modules are wired independently of the ring wiring
- If the wiring were to break for those modules only that module would cease communication



32

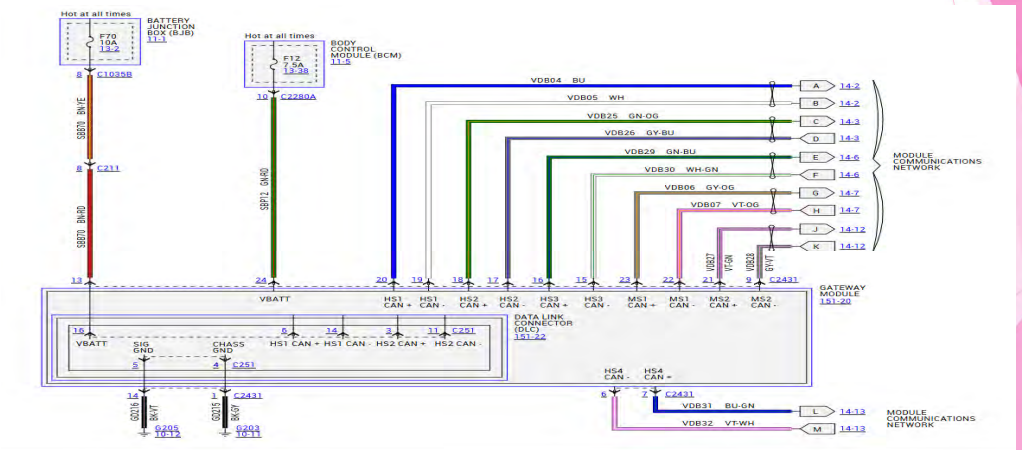
Physical Layer

- Gateways
- A central control module that directs messages
- Ties multiple communication bus types together
- Allows for a connection to the scan tool
- Maybe a standalone module or part of another module
- Most do not provide a physical connection from an outside Node (scantool) to directly connect to the bus



33

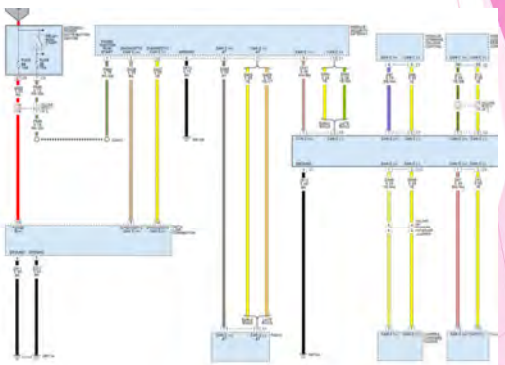
Gateway



34

Physical Layer

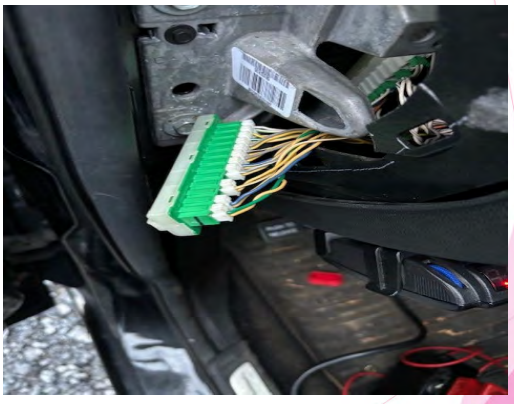
- Secure gateways
- Do not provide a direct connection from an external device to the bus
- The tool connected to the gateway must also pass additional security protocol to allow it to pass information through the gateway to the bus
- If the clearance is not passed only OBD mandated communication for emission purposes will be allowed
- Testing at the DLC only checks the connection from the DLC to the secure gateway



35

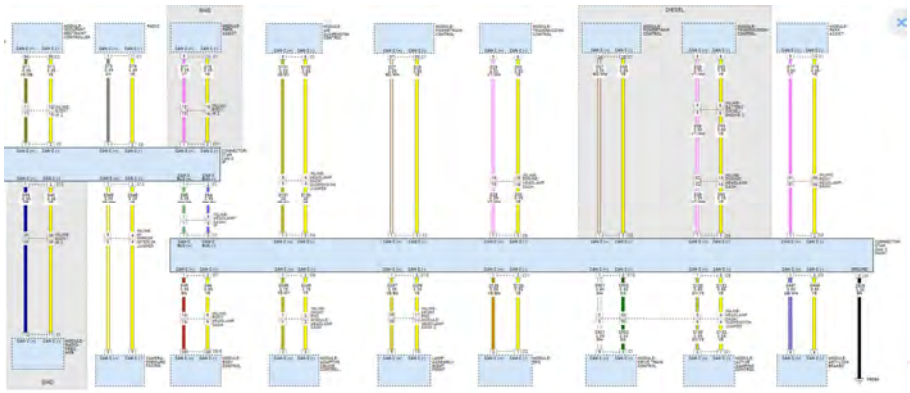
Physical Layer

- Some systems include junction connections that join the circuits together at a common point
- Chrysler calls them star connectors
- High failure rate
- Has terminating resistors inside
- Very small pins create poor terminal contact and often result in intermittent issues
- Typically several of them are used
- Can be disconnected to split the system for diagnosis



36

Star Connector



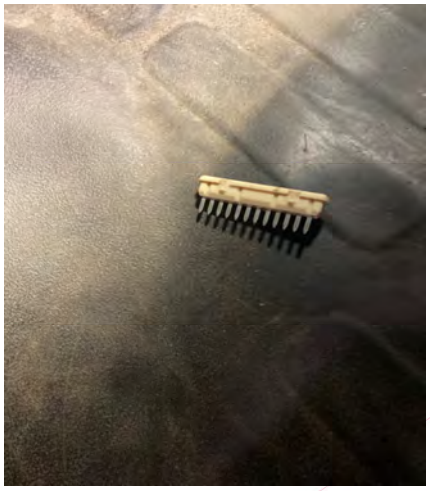
37

Physical Layer

- GM uses a connector similar to the star connector
- Used for Low Speed LAN and Class 2
- Provides a good access point to test module communication circuits individually located inside the vehicle
- Connector numbers will use zoning:

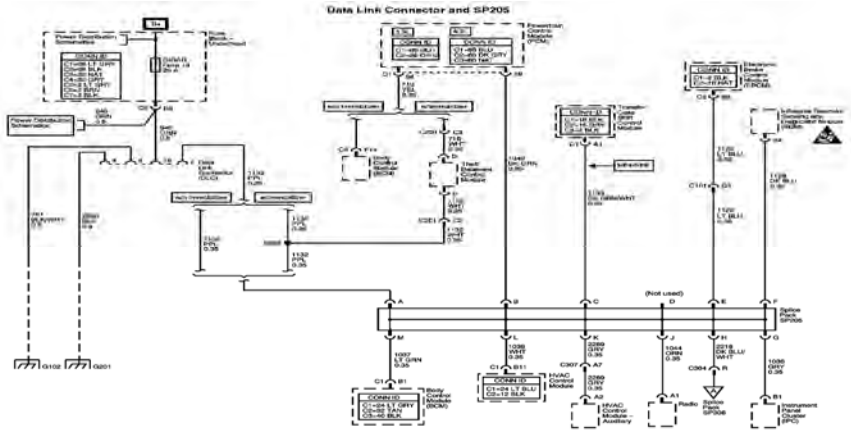
38

Splice Pack



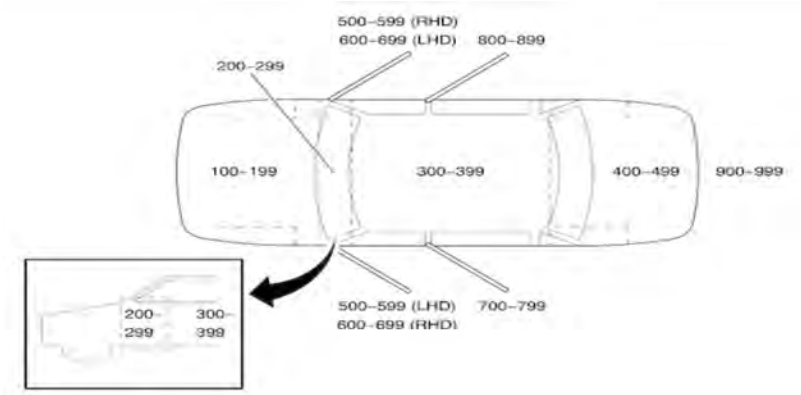
39

GM Class 2 Splice Pack



40

GM Harness Zones



41

Case Study 2004 Silverado 6.0L

- Truck at a shop
- Only description I get “I don’t know, it won’t crank or do anything”
- Visual inspection shows the underhood fuse box is apart but no new parts found anywhere
- Open the driver door
- No interior lights
- Now what?

42

2004 Silverado

- Who said this mobile diag thing is awesome?
- 6 inches of snow last night current temp 11°F
- No room in shop
- I have a problem taking a production bay in the shop anyways
- So, we will see what we can find outside
- Besides, working in the cold will speed me up!

43

What should we do first?

44

2004 Silverado

- No dome lights
- Charged battery
- Now when turning the key on there is a 3-4 second delay before the dash lights up
- When the dash does light up, none of the gauges work but the gauge sweep works
- Does not crank
- No PRNDL indicated

45

2004 Silverado

- Check battery voltage has charger on it
- Quick voltage drop test of the body and engine to battery negative OK less than 100 mv
- Voltage drop test battery positive to main lug in the fuse box and a few larger maxi fuses less than 100 mv
- Now what?
- Hook up scan tool.

46

2004 Silverado

- Scanner connected
- Does self identify the truck
- OK cool some communication going on
- Scan all modules
- Can only communicate with the instrument cluster, BCM and air bag
- Can not communicate with PCM, ABS, Door Modules, Radio, Transfer case, HVAC

47

Silverado

Has Communication

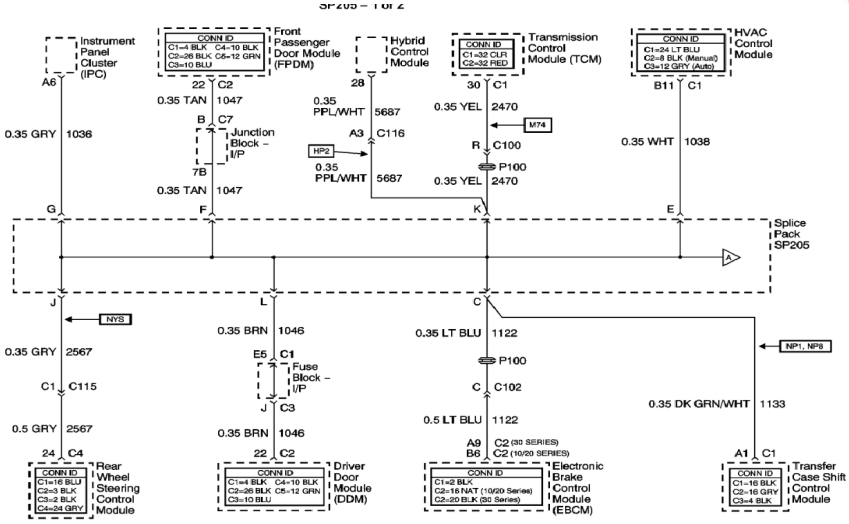
- BCM
- IPC
- SRS

No Communication

- PCM
- Transfer case
- ABS
- Doors
- Radio
- HVAC

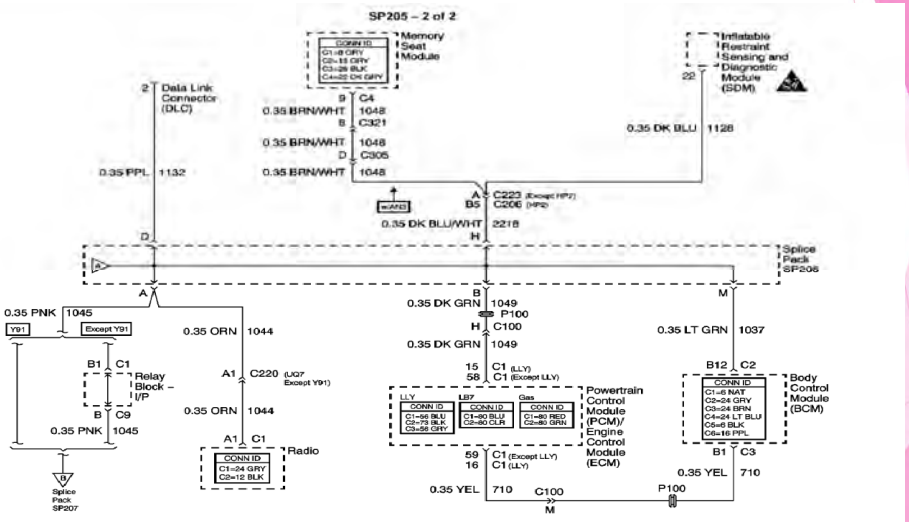
48

Communication



49

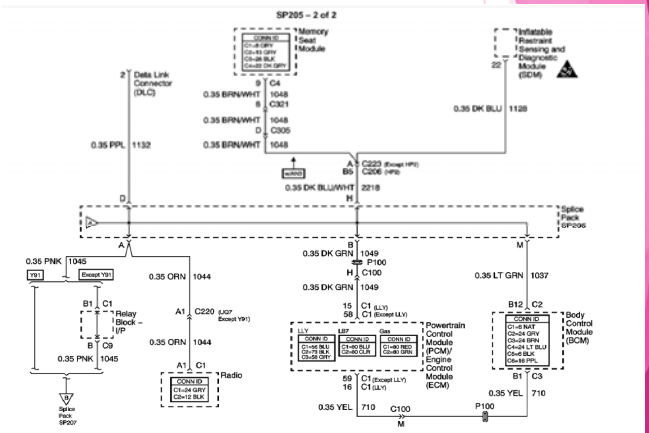
Silverado Communication



50

Silverado Communication

- What does a module need to allow communication? _____, _____, _____
- What type of communication is this?
- How are the modules connected?
- What are the operating voltages?
- What do the communicating modules have in common?
- What do the non-communication modules have in common?

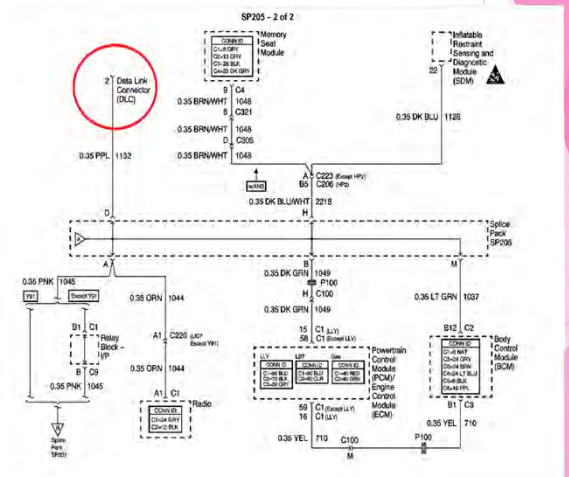


51

Communication type

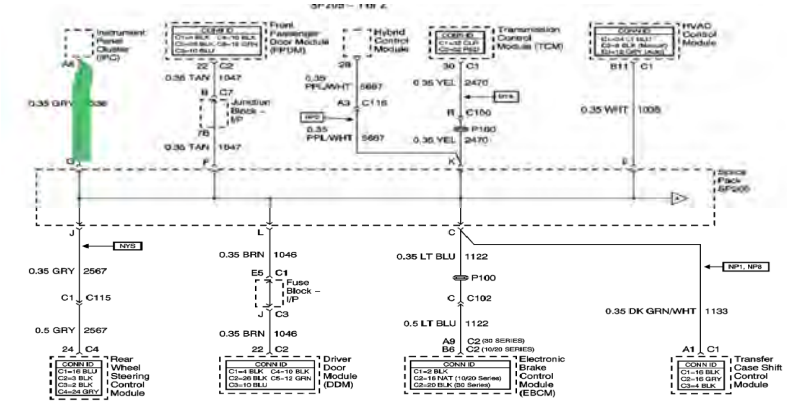
PIN	DESCRIPTION	PIN	DESCRIPTION
1	Vendor Option	9	Vendor Option
2	J1850 Bus +	10	j1850 Bus
3	Vendor Option	11	Vendor Option
4	Chassis Ground	12	Chassis Ground
5	Signal Ground	13	Signal Ground
6	CAN (J-2234) High	14	CAN (J-2234) Low
7	ISO 9141-2 K-Line	15	ISO 9141-2 Low
8	Vendor Option	16	Battery Power

OBD-II Connector and Pinout



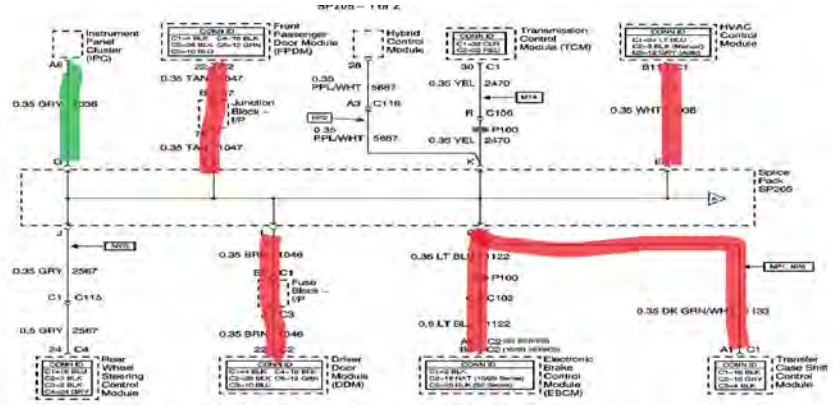
52

Mark Good Comm



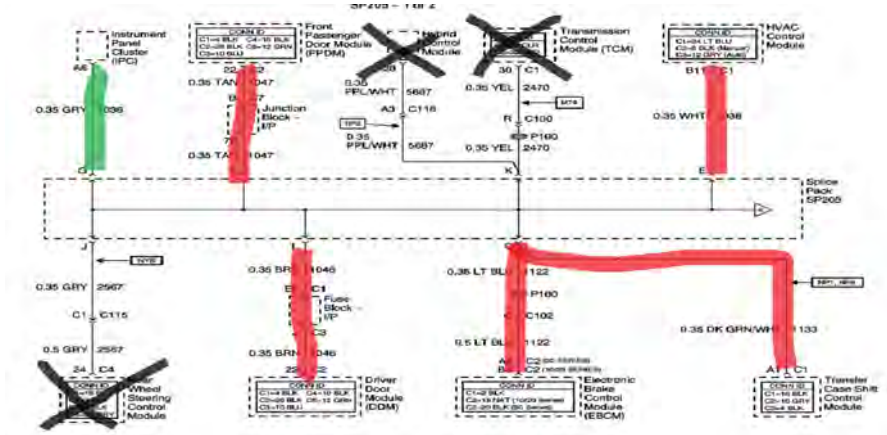
53

Mark No Comm



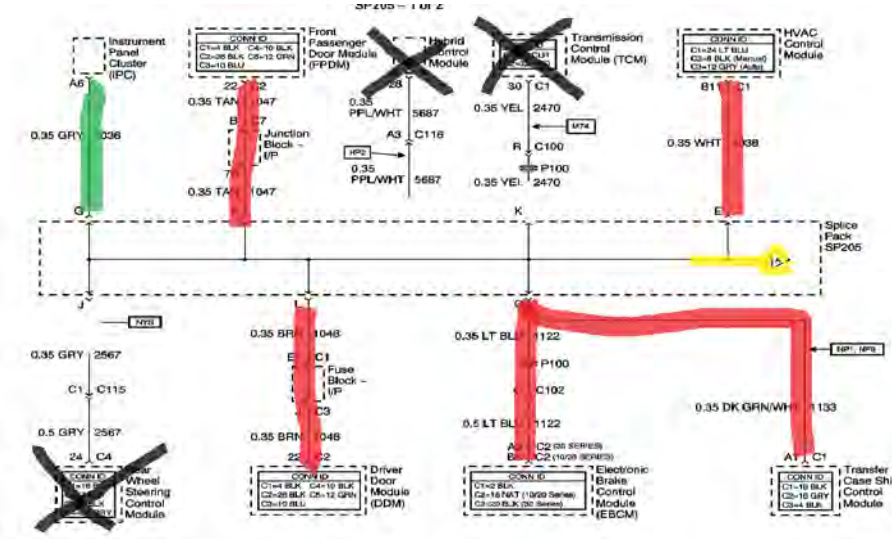
54

Mark modules not used



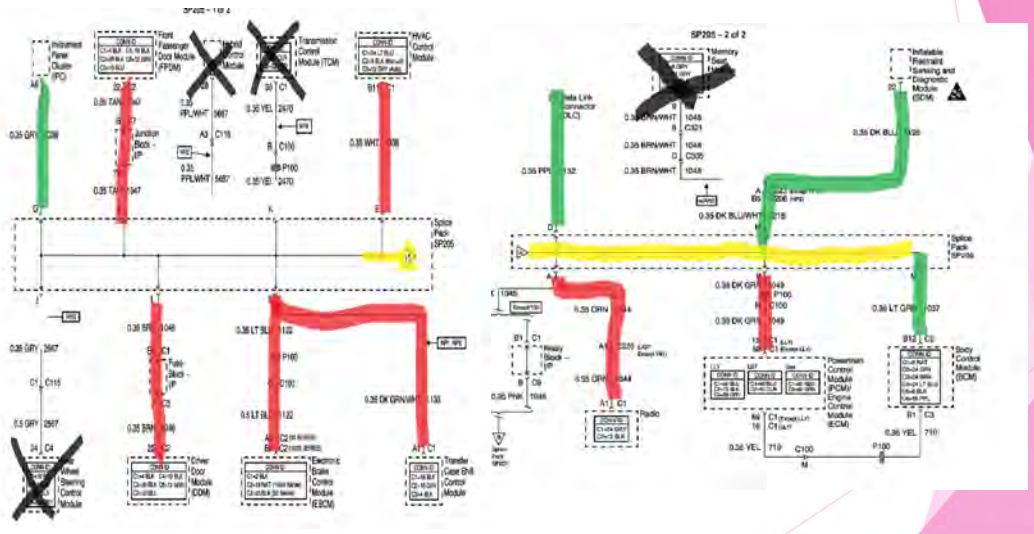
55

Remove unused module connections



56

Complete communication



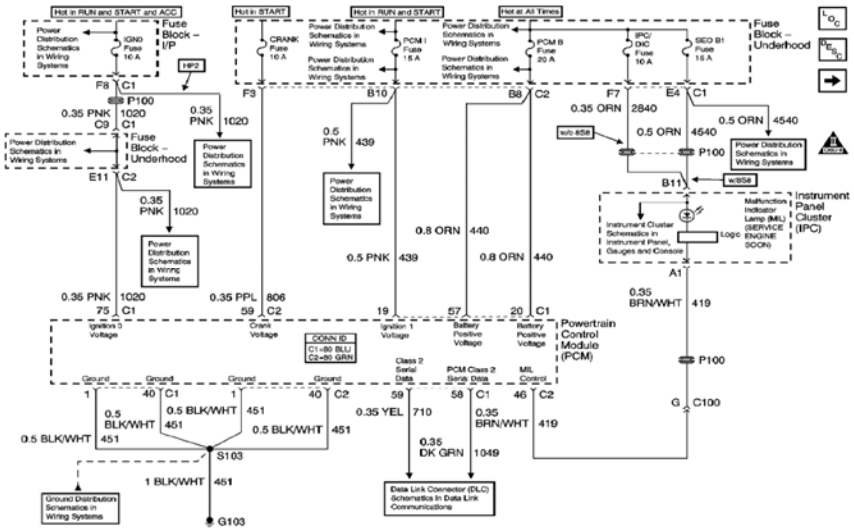
57

Silverado review

- So, the physical layer is at least partially OK because we can establish communication from PIN 2 of the DLC to modules on splice pack SP205
- Now what?
- We need _____, _____, _____ for communication
- We have some comm. Could the wires from the splice packs to the non communicating modules be bad? Yes, but what are the chances they all have issues?
- We also need to check power and grounds. Do they share common powers and grounds? Let's look at just a couple modules to see if they share a power and ground
- One thing to consider, the radio has no comm, but it plays. So, it must have power and ground.

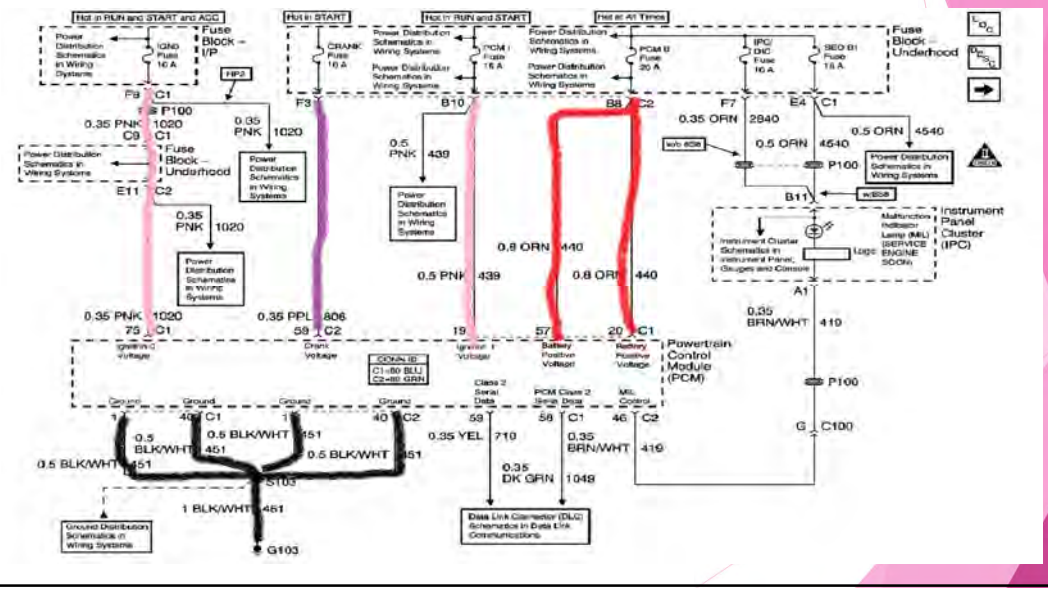
58

PCM Power and Grounds



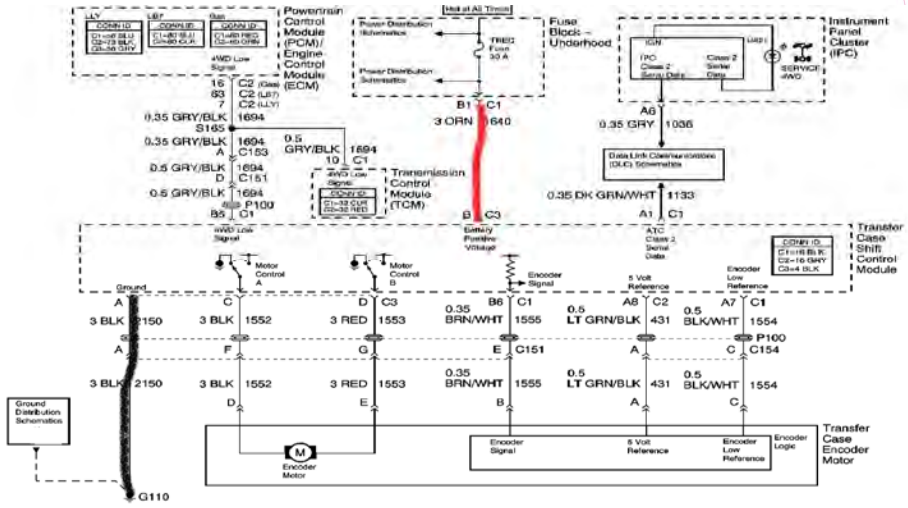
59

PCM Power and Grounds



60

Transfer case power and grounds



61

Power and Ground Comparison

PCM Power and Grounds

- IGN 0 Fuse 10 A IP Run/Start
- Crank Fuse 10 A UH 10A Run/start
- PCM1 Fuse 15 A UH Run/start
- PCM B 20 A UH Hot at all times

TCCM Power and Grounds

- TREC Fuse 30A UH Batt
- Ground G110

62

What now?

- The TCCM and PCM do not have any common power and grounds
- So now what?
- Should we go to the modules and check power and grounds?
- Should modules be accessed to check communication wires continuity?
- What can we do to get the most results the quickest?
- Where is a common spot to test all modules for communication signals?
- Where is a common spot to check each module for individual communication?

63

Check communication

- I decide to test at the DLC pin 2 for signals to see if anything looks odd
- Use a DLC breakout box, 1 channel scope
- No communication is taking place. No change in voltage, but rest voltage is not at 0.
- Is this OK?
- Remember how class 2 works?

64

Check communication

- Woah!!
- DLC Pin 2 indicates a constant voltage around 8 volts
- What can cause this?
- A short to power communication line?
- A failed module?
- Short to ground communication line?
- Open communication line?

65

Class 2 Data

- Constant 8 volts on class 2 line
- What now?
- Likely culprits:
- Communication line shorted to power
- Failed module
- Poor ground
- Remember those splice packs?
- We can isolate modules there and test each one individually

66

Splice pack 205

Splice Pack

Splice Pack Comb

67

Splice Pack 205

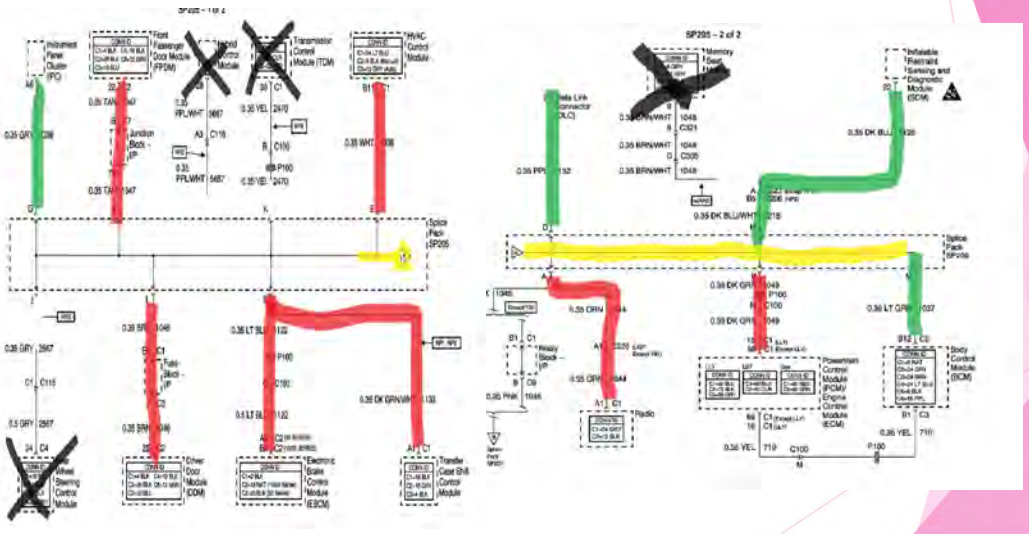
Connector

- Located under the dash near the fuse box
- Has connections for:
- SRS
- DLC
- PCM
- TCCM
- BCM
- Radio
- ABS
- DDM
- HVAC
- IPC
- PDM

Connector

68

Complete communication



69

Module Comm to PIN in SP205

- A=Radio
- B=PCM
- C=ABS
- D=DLC
- E=HVAC
- F=PDM
- G=IPC
- H=SRS
- I=Blank
- J=Blank
- K=blank
- L=DDM
- M=BCM

70

Splice comb removed

- Once the comb is removed the voltage in DLC Pin 2 falls to 0
- That indicates the Pin 2 wire is connected and not shorted from the DLC to SP205
- So now check each module communication circuit individually at the SP205
- Look for the ones with normal communication, no communication but resting at 0 and for ones resting at 8ish volts

71

Good Communication

- Several Pins in SP205 are at 0 volts or communicating normally
- Those modules are OK

72

SP205

73

SP205

Stuck High

Pin M

74

SP 205

Pin B

Stuck High

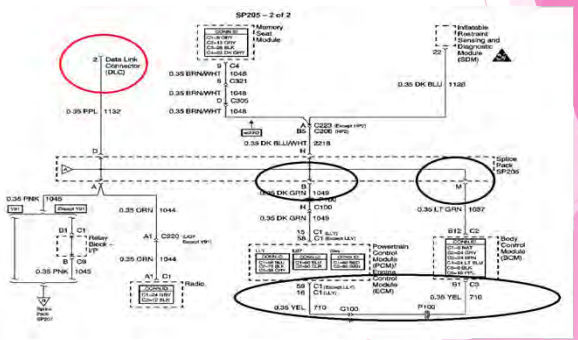
75

SP 205

Connections at SP205

- Pin B=PCM
- Pin M=BCM
- Both stuck around 8 volts
- Why 2 modules with communication issues?
- What can cause this?
- BCM and PCM connected at the splice pack AND a dedicated wire between the 2
- I think the issue is with the PCM and it is affecting the BCM Why?
- Because we could communicate with the BCM but not the PCM

Pin B and M in SP205



76

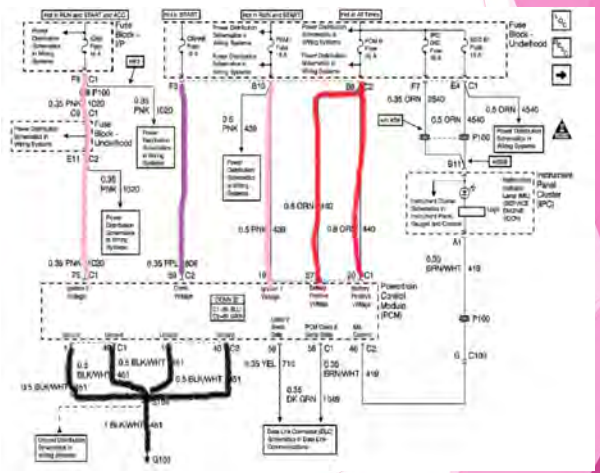
BCM and PCM Communication Stuck High

- Since the BCM has sporadic communication and the PCM never has communication I decide to test the PCM first
- What should the PCM be checked for?
- _____, _____, _____
- Power? Not likely it is showing voltage on the comm line
- Ground? Possibly a bad module ground can not pull a communication circuit to ground
- Communication circuit? Possibly, could be shorted to voltage
- Internally failed PCM? Definitely suspect, but what should be checked first?

77

PCM Power and Grounds

- We can access the PCM to check all of the powers, grounds and communication circuits
- But: it's 11°F outside and I don't want to dig out the PCM
- Where else can they be tested?
- I want to focus on the grounds first, other than the module the ground is the most likely concern



78

Testing Grounds

- If the PCM has lost it's ground it should affect other PCM circuits
- Let's check a ground circuit that is easy to access
- The easiest one is at the MAF sensor
- Terminal A of the MAF is a reference ground supplied from the PCM
- It shows 9 volts when meter is referenced to battery ground!!!
- No PCM ground to the MAF!

79

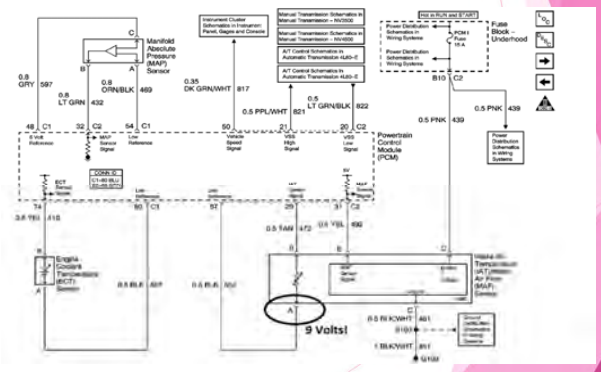
Testing Grounds

80

Checking Grounds

Connected to MAF

MAF circuit

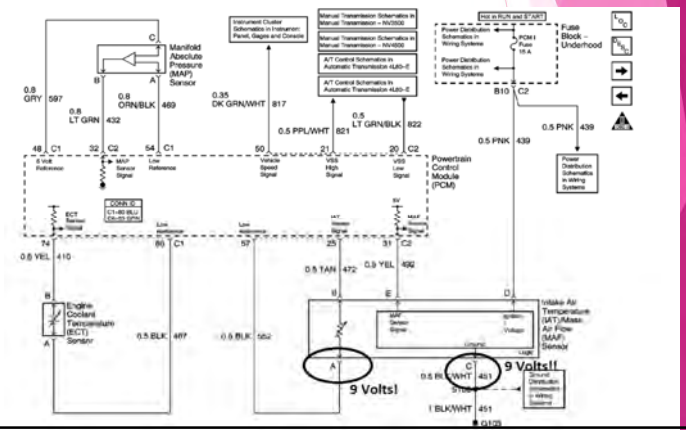


81

Ground testing

MAF Ground Pin C is G103 the PCM Ground!

MAF Ground Connection

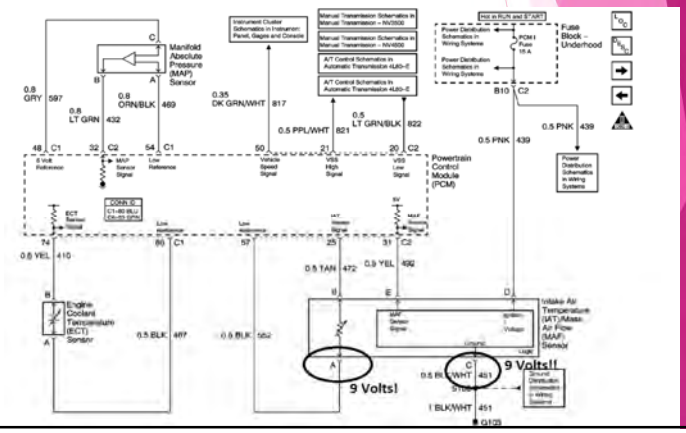


82

Ground testing

MAF Ground Pin C is G103 the PCM Ground!

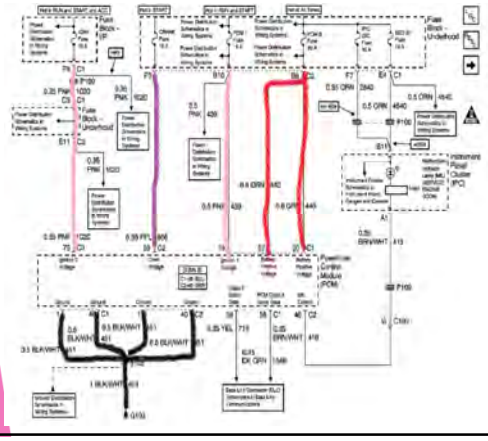
MAF Ground Connection



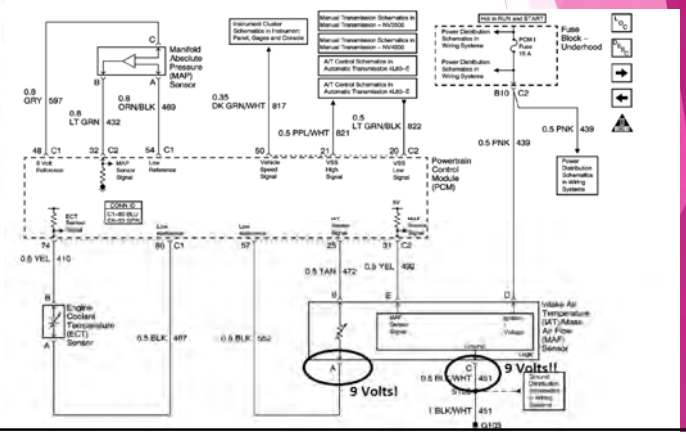
83

Ground testing

MAF Ground Pin C is G103 the PCM Ground!



MAF Ground Connection



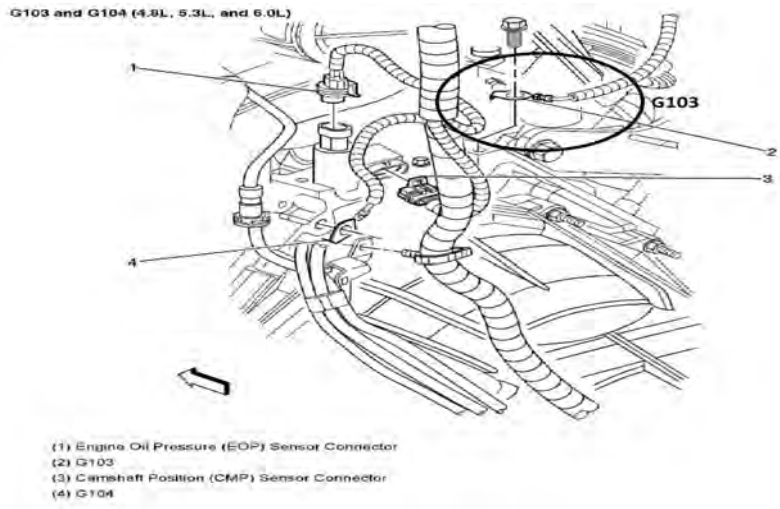
84

Ground Testing

- MAF PIN C is connected to G103
- G103 is also the connection for ALL of the PCM grounds
- PCM has definitely lost it's ground because the MAF reference ground is also 9 volts
- Need to locate G103

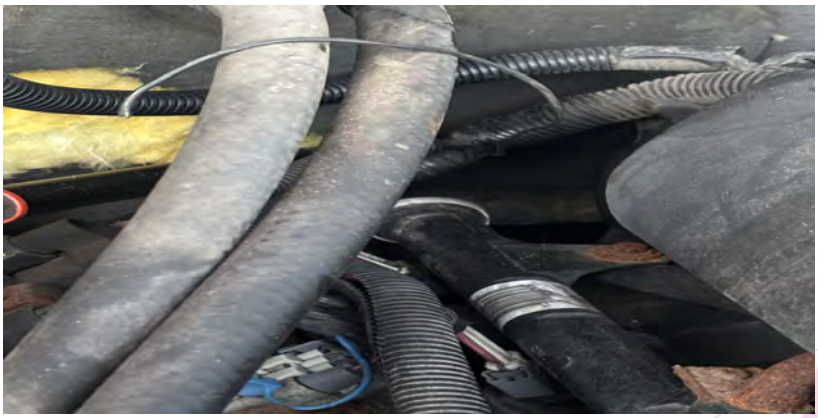
85

Ground G103 Location



86

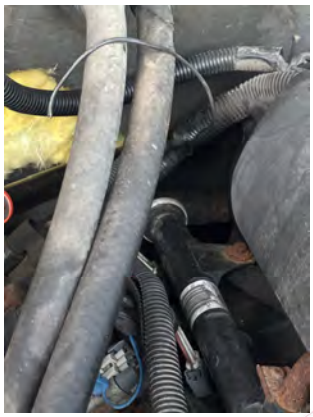
Ground G103



87

G103

- Found G103 broken in the back of the engine
- Attached new eye terminal and reattached
- Reassembled SP205 and started truck
- Cleared all codes
- Verified no codes returned



88

Silverado Case Study Recap

- No start
- No com with several modules
- Class 2 voltage stuck at 8V
- Removed splice comb to test module communication lines individually
- Found PCM and BCM causing elevated voltage
- Decided to test PCM first because BCM had comm
- Tested PCM grounds at MAF
- Found MAF reference ground at MAF was 9 volts instead of 0
- Also found MAF used G103 same as ALL the PCM grounds and that also had 9 volts
- Located broken G103 wire under the intake manifold

89

Modern Systems

- Most modern systems use similar type protocols
- Most common is the Can Bus
- Controller area network
- Some may use the Can bus but rename it to the manufacturer
- An example of that action is GMLAN
- Other modern systems may include:
- Flexray
- Flexible can
- Private single wire busses
- Low speed busses similar to GM low speed LAN

90

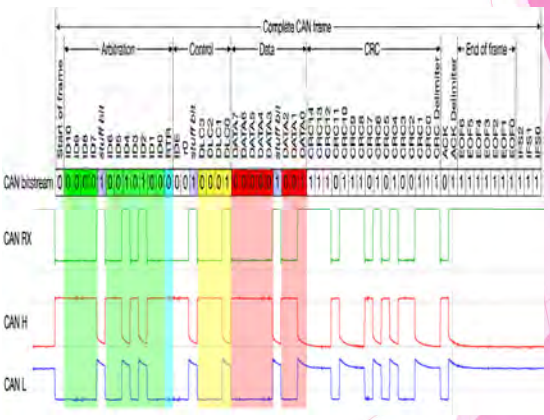
CAN Systems

- The automotive CAN bus was developed by Robert Bosch in 1986
- First used on a Mercedes Benz W140 in 1991
- CAN- Controller Area Network
- CAN uses a chip to send clocked messages through a network of wiring allowing modules to communicate
- 2 wires systems
- Architecture similar to J1850 PWM
- Speeds up to 500kbps
- Can be different speeds
- Some manufacturers use assigned names such as GMLAN GM Local Area Network
- Used by almost every manufacturer

91

CAN Bus

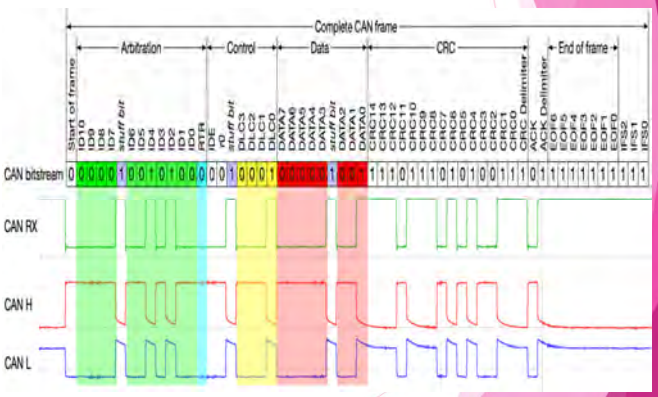
- Message construction similar to J1850
- Is a voltage differential bus
- 2.5 volts is the idle (recessive) voltage
- Can high is pulled to 3.5 (dominate)
- Can low is pulled to 1.5 volts (dominate)
- This creates a 0 recessive and a 2 volt dominate bit



92

Can Messaging

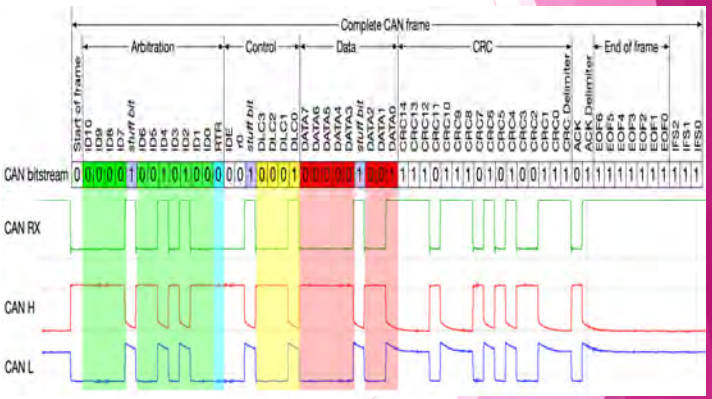
- When the voltage is pulled dominate (2-volt differential) this will create a 0 bit
- When the voltage is at idle, recessive (O-volt differential) this will indicate a 1 bit
- So switching off bias creates a 0
- When remaining at bias voltage a 1 is created



93

Can Message Construction

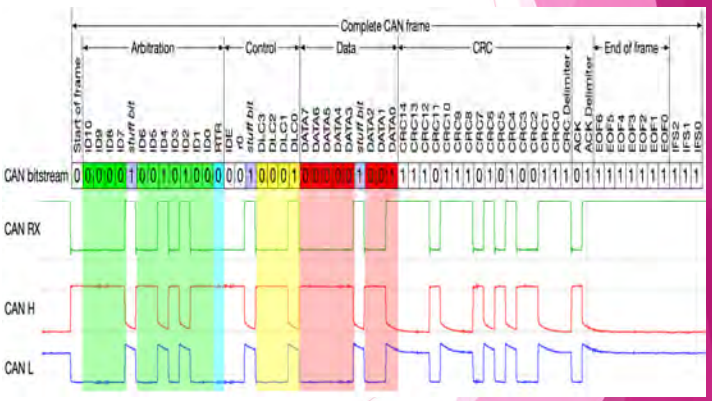
- There are 7 areas to a can message
- SOF: start of frame, message beginning
- Arbitration: Identifier, importance of message, who should receive the message
- Control: a series of check bits to be sure the message is valid
- Data: the actual message
- CRC Cyclic Redundancy Counter: another series of check bits



94

Can Message Construction

- ACK Acknowledge:
- ACK slot: module transmits a recessive 1
- Receiving module that needed the info can change this bit to a dominant 0 indicating the message was received
- If the bit is not changed from 1-0 then the module that sent it may continue to broadcast it until another accepts it
- ACK delimiter must be a recessive 1
-



95

Arbritration

- So many modules transmit data on the same 2 wires that there must be a way to prioritize messages
- The arbitration frame handles the initial call
- The frames in the arbitration data will decide which message is most important
- The bits should be a dominate 0
- If the module transmits a recessive 1 in one of the frames then that indicates it has lost arbitration and any module that continues to broadcast a 0 will continue to win arbitration and take over the bus

	Start bit	ID bits											The rest of the frame
		10	9	8	7	6	5	4	3	2	1	0	
Node 15	0	0	0	0	0	0	0	0	1	1	1	1	
Node 16	0	0	0	0	0	0	0	1	Stopped Transmitting				
CAN data	0	0	0	0	0	0	0	0	1	1	1	1	

96

Arbitration

- If a module always broadcasts 0 in the arbitration and the ACK bit never gets changed to a dominate 0 then that module can continue to tie up the bus
- This is obvious when the same message is repeated constantly resulting in a tied up bus and no other message can be sent from any other module until the bus is free
- Sometimes these messages will time out, other times they can completely tie up a bus and prevent any communication from occuring

	Start bit	ID bits										The rest of the frame
		10	9	8	7	6	5	4	3	2	1	0	
Node 15	0	0	0	0	0	0	0	0	1	1	1	1	
Node 16	0	0	0	0	0	0	0	1	Stopped Transmitting				
CAN data	0	0	0	0	0	0	0	0	1	1	1	1	

97

Arbitration

- If a module broadcasts a message that is intended for a specific module, and the module receiving the message does not change the ACK slot bit the message continues to repeat
- This image is a CAN High 2013 Malibu at the FPCM, the ECM is trying to communicate with the FPCM and communication is not established, so the message just repeats

98

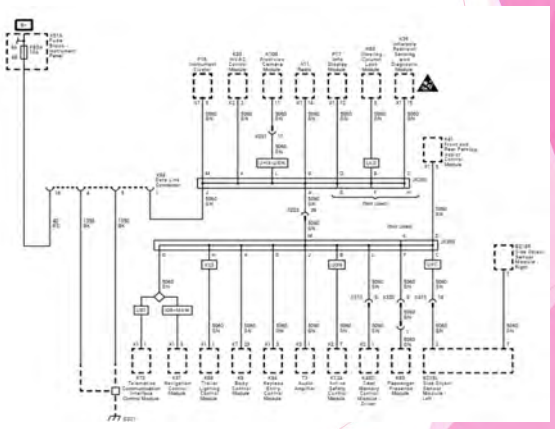
GM Low Speed LAN

- GM Low speed LAN is a single wire low speed circuit similar to class 2 data
- Typically located on DLC PIN 2
- 0-5 volts
- 0 volts at rest (recessive) bit 1
- Pulls high to 5 volts (dominant) bit 0
- Slow speed about 33kbps
- Typically used for audio, doors, cluster, other items that do not require fast communication speeds
- Attached to DLC PIN 1
- Similar to J1850 VPW

99

GM Low Speed LAN

- Wired in star configuration
- Uses junction connectors to attach modules
- Can remove modules from these splices to test module faults
- Simple bus to diagnose
- May connect to a serial gateway or the BCM to control the circuit



100

F-CAN

- Up to 8 times faster than traditional CAN
- Up to 1mbps
- Uses the same type traditional CAN chips
- Introduced around 2020
- Allows for future faster modules

The frame format is as follows. The bit values are described for CAN-LO signal:

Field name	Length (bits)	Purpose
Start-of-frame (SOF)	1	Denotes the start of frame transmission
Identifier (ID)	11	A (unique) identifier which also represents the message priority
Stuff bit	1	A bit of the opposite polarity to maintain synchronisation, see CAN Bus#Bit stuffing
Remote Request Substitution (RRS)	1	
Identifier extension bit (IDE)	1	
FD Format Indicator (FDF)	1	Must be recessive (1) for CAN FD frames and dominant (0) for classic CAN
Reserved bit in FD frames (res)	1	
Bit Rate Switch (BRS)	1	
Error State Indicator (ESI)	1	
Data length code (DLC)	4	Number of bytes of data (0–64 bytes)[a]
Data field	0–512 (0-64 bytes)	Data to be transmitted (length in bytes dictated by DLC field)
CRC	15	Cyclic redundancy check
CRC delimiter	1	Must be recessive (1)
ACK slot	1	Transmitter sends recessive (1) and any receiver can assert a dominant (0)
ACK delimiter	1	Must be recessive (1)
End-of-frame (EOF)	7	Must be recessive (1)
Inter-frame spacing (IFS)	3	Must be recessive (1)

a. * The values 0-8 indicate 0-8 bytes like classic CAN. The values 9-15 are translated to a value between 12-64 which is the actual length of the data field: 9→12 10→16 11→20 12→24 13→32 14→48 15→64

101

Flexible CAN

- F-Can or Flex Can is similar to can except there is additional bytes present up to 64 (254 bits) in the message area of the can message to relay more data per transmission
- This speeds up communication because more data can be transmitted in one message instead of creating a whole new message with the complete construction
- More modern communication type in systems with several modules requiring rapid data transfer
- Does not need to use the additional bits in the message area which is why it is flexible can
- The identifier is also longer moving from 11 bits to 29
- Each area of a message is known as a frame

102

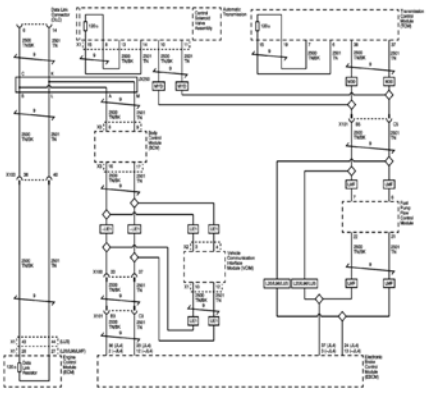
CAN Testing

- Can networks have 2 resistors on each end of the bus
- The resistors are placed in parallel
- 2 120 ohm resistors in parallel will result in a total circuit resistance of 60 ohms
- Checking the resistance of a can bus is a valuable test to verify the physical layer
- Check both bus wires together=60Ω
- Check each bus wire to chassis ground=OL
- Vehicle must be powered down and communication off
- If equipped with a gateway may need to test each bus separate after the gateway
- May have a dedicated resistance for diagnostic can DLC-GWM

103

Testing

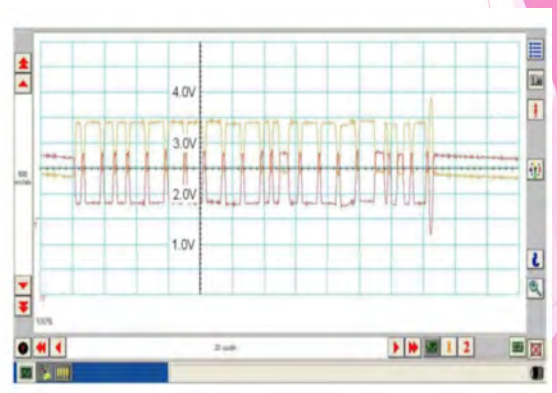
- Test at PINS 6,14 at the DLC
- Different busses may use different pins reserved for CAN
- Resistance should be 60 ohms
- 120Ω indicates ½ of the circuit is open
- Less than 60Ω indicates a short somewhere
- Can wiring to chassis should be infinite resistance



104

Scope testing

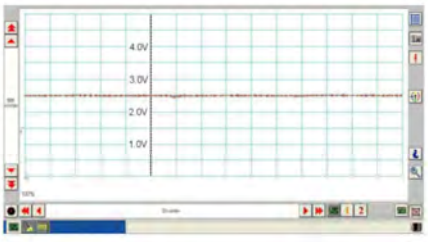
- Once the physical layer has been verified a lab scope should be used to verify communication
- Errors in the messages can be easily spotted using a scope
- A normal pattern is displayed
- Note the clean switch from 2.5-3.5 volts and 2.5-1.5 volts
- The spike at the end indicates end off message, this spike may occur in the beginning to wake up a bus or to indicate a start of a high priority message
- Often scan tool communication voltage is greater than normal messages from the modules



105

Message Faults

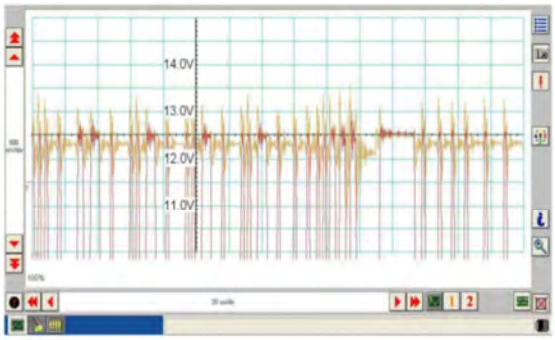
- Can high and low shorted together is indicated
- Note the nominal voltage of 2.5 that remains steady
- If this is found, make an attempt to wake up the bus to start communication



106

Message Faults

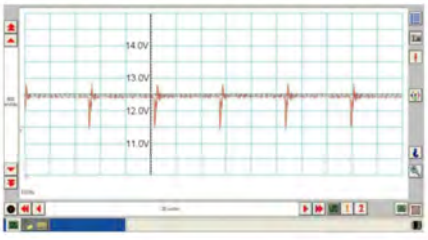
- A can circuit shorted to voltage is indicated here
- Note the voltage near battery voltage.
- Issue can be caused by a shorted module, harness or even water in a chassis connector



107

Message Faults

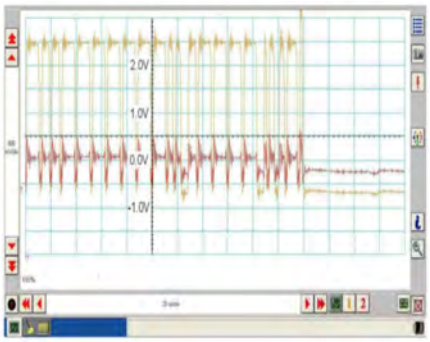
- Can negative shorted to voltage
- This will also cause the bus voltage to move near battery voltage
- Note the message can still try to occur but less strong than the can + shorted to voltage



108

Message faults

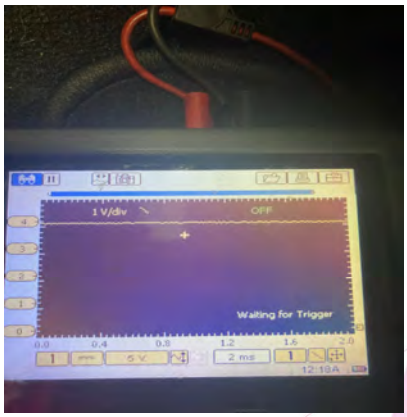
- Can negative shorted to ground
- The can positive will pull to zero at rest but is able to go to about 3 volts when commanded high
- Remember the high and low circuits are connected through the terminating resistors which allows a fault to occur on both busses



109

Message faults

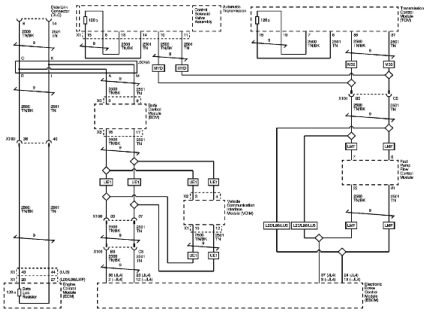
- The image shown is Can High
- Truck was a no start
- No power when the key was turned on
- Thinking it maybe a BCM fault, Can bus was scoped
- Note the very high voltage without the presence of any messaging
- What could cause this?



110

Can DSO Testing

- Typically we were taught to test the CAN circuits by measuring CAN High and Can Low to chassis ground
- This is a differential bus
- The modules are actually looking for the difference voltage not the voltage to ground
- So we can measure the CAN circuits as one circuit: red to can high, black to CAN low
- This wills how if the differential voltage is proper
- But if the voltage is not proper it may be easier to measure circuits to ground to determine which one has the fault



111

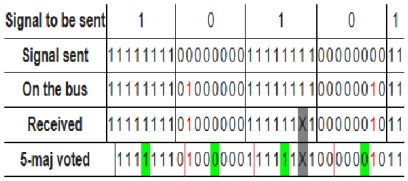
FlexRay

- Super fast
- Up to 10mbps
- Uses a communication controller to prevent message collision on the bus
- Used in very fast demanding areas such as:
- Brake by wire
- Steer by wire
- Typically wired in hybrid mode with ring and star configurations
- Used by Euro manufacturers

112

FlexRay

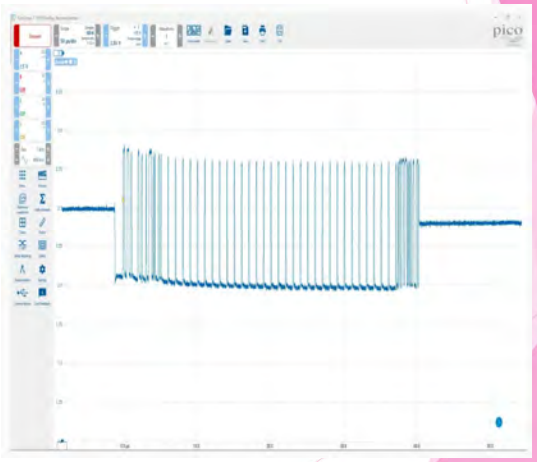
- Clocked signals in each module
- A clock makes the signals synchronous
- The master module sets clocks
- The clock drift must not exceed .15%
- Two wire system
- Typically uses a gateway as the master



113

FlexRay

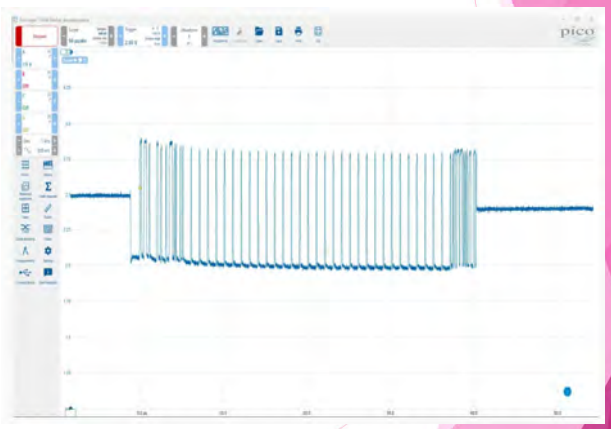
- Still uses a 2.5 volt bias
- Instead of can high and can low:
- BP=Bus plus
- BM=Bus minus
- With a zero volt differential, an idle state is detected
- The amount of time the bus stays idle will help to sync the clocks in all the modules



114

FlexRay

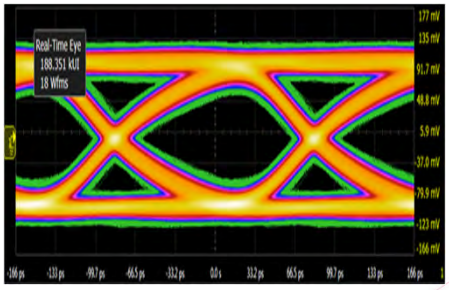
- The system is a differential bus
- When BP is pulled low to 1.5 volts and BM is pulled high to 3.5 volts the result is a -2 volt reading
- If BP is pulled high to 3.5 volts and BM is pulled low to 2.5 volts a +2 volt differential is created
- Because the BP can go high or low and BM can go high or low they will both cross the bias plane in time
- Signal is very fast 10mbps
- Uses terminating resistors, two 100Ω resistors in modules in parallel will result in a bus resistance of 50Ω



115

FlexRay

- Because both BP and BM pass through the bias, and the speed is very fast it can be difficult to detect the switches and messaging with a traditional DSO
- A very fast scope can be setup to an eye mask
- An eye mask is a voltage capture that marks an area, when the BP and BM move they can be compared to a preset voltage area setup with an eyemask ensuring the signal does not travel outside a preset zone, which would indicate voltage drift or signal interference



116

FlexRay Testing

- Measure bus resistance should be 50Ω
- Has 2 100Ω resistors in series similar to CAN
- 100Ω will indicate open physical layer or damaged module
- Also like CAN be sure to check resistance to chassis ground should be OL
- Use of a traditional DSO may result in very skewed images due to the bus speed
- Should use a scope designed for FlexRay with attenuators to create an eyemask to measure
- Link to eyemask testing for FlexRay
- https://www.testequity.com/UserFiles/documents/pdfs/keysight/can_eye-diagram-mask-testing-an.pdf

117

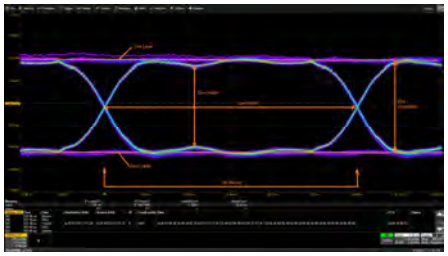
Ethernet

- Ethernet is a vey fast method of communication
- Typically 2 wires
- Not used on all modules, only ones that require very fast messaging
- 100mbps
- Typically used for ADAS components
- Also used for audio
- Tesla uses it for scan tool communication, because a Tesla is a PC on wheels
- Not a typical differential bus
- Each lead of the Ethernet is a single circuit
- Voltage plus and minus may be compared to one another, but they are not used to measure a voltage differential

118

Ethernet

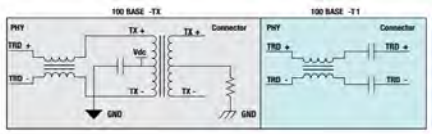
- Diagnosis is used with a labscope
- Because this is not a typical differential voltage, the wiring will need to be interrupted with a differential device
- Each of the 2 wires through the decoding device will be attached to a channel



119

Ethernet Physical Layer

- Expensive
- Requires switches
- Adds weight
- Very fast
- Very small connectors
- Cables unshielded to save weight and cost
- Must compensate for noise



120

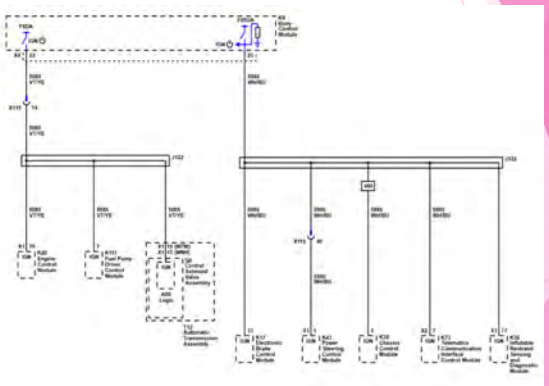
Wakeup

- Most new systems do not use a dedicated ignition circuit for each module to wake it up
- There are a couple different ways the modules can be woke
- Modules go to sleep at different voltages, so base voltage is important
- If supply volts go low, and module processors turn off at different voltage levels, one module may turn off while others are communicating this causes communication codes to set in the modules that are still broadcasting

121

Wakeup

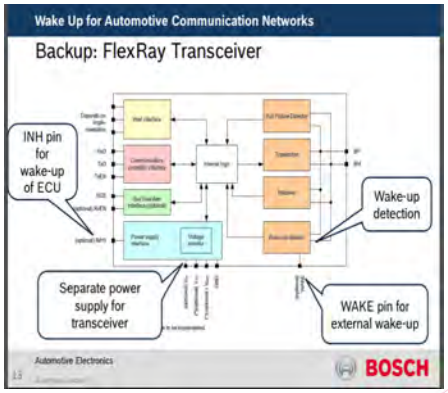
- It is common for one module to send a module wakeup
- Typically the power mode master is the module commanding the other modules on
- The PMM will receive voltage from the controls like push to start, then once that signal is decoded the PMM will send a dedicatedhardwired signal to all of the modules to wake them up, typically this is a 12 volt low current signal



122

Wakeup

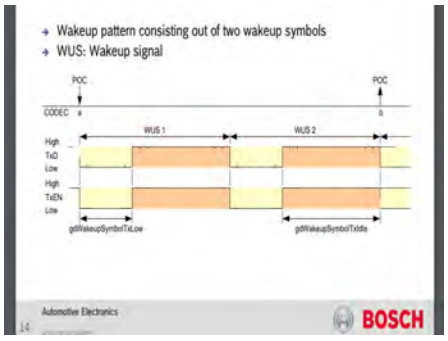
- Another way to wakeup the modules is to alter the voltage on the communication circuits
- Pushing a can voltage over the normal 3.5 volts to say, 5 volts could provide a wakeup signal to a module
- This is advantageous because no additional hardware or wiring is required



123

Wakeup

- Additionally a signal can be created on the bus to perform wakeup
- Using a arbitration that is high to be accepted by all modules
- Installing long dominant and recessive bits in the beginning of a message can signal the modules to wakeup



124

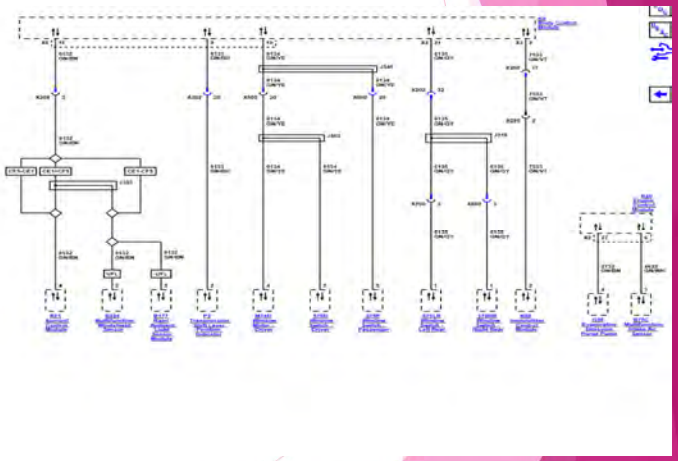
Local Interconnect Busses (LIN)

- Single wire bus
- Used for private messaging
- Not connected to the DLC
- Typically one or two items will communicate on the same LIN circuit
- Can be used to control outputs like alternator voltage regulators
- Slow 20kbps
- 0-12 volts
- 12 volts is recessive a 1 bit
- O volts is dominate and a 0 bit
- 12 volts is usually created in the device and pulled to ground in the module controlling the item to create a signal

125

LIN

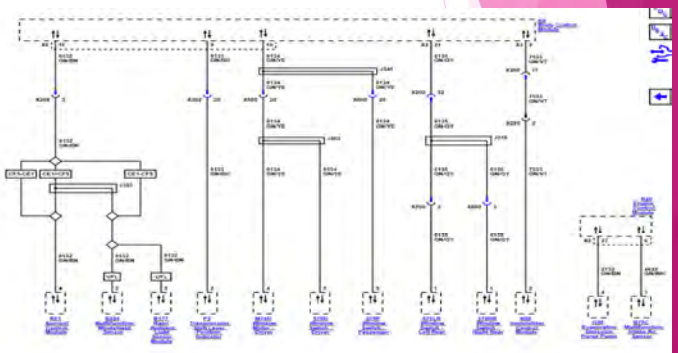
- Since the voltage is normally high and pulled low to become dominant, an open circuit would result in 12 volts present at the unit
- A short to ground would result in 0 volts at the module and the output
- If multiple outputs are on a LIN bus and none of them are working, likely a shorted module, measure voltage at supply module if near 0 circuit is shorted



126

LIN

- Typical controls for LIN:
- Windows
- Alternators
- Radiator shutters
- Cooling fans
- Fuel pump controllers



127

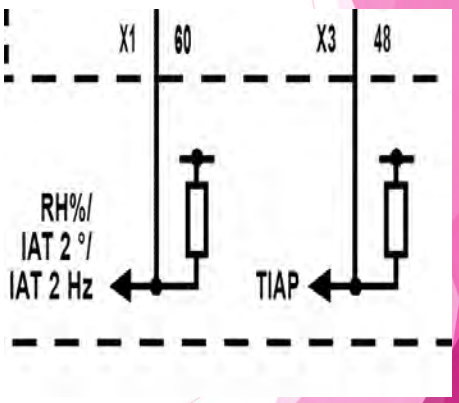
LIN Testing

- Can use a meter to check voltage
- Will show average
- So should be more than 0 and less than 12 depends on the amount of time the line is pulled low by the module
- A DSO is very useful
- Will display 12 volts at control module if wiring is OK from module to control
- Measuring voltage at unit is not helpful if communication is not present, but if the 12 volt circuit is cycled to ground at the controlled unit (alternator), then the wiring is intact

128

Sensor data

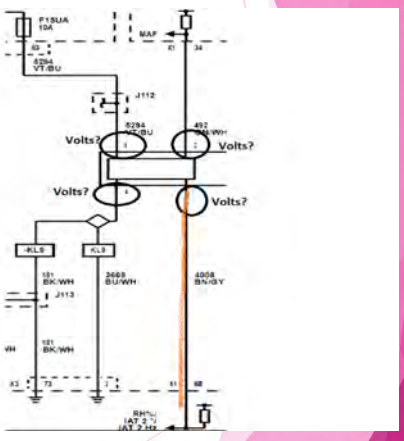
- Sent sensor
- Sent sensor uses a digital signal to communicate with the module
- The digital signal is created in the sensor, pulling the 5 volts created in the module to ground then report:
- Relative humidity %
- Intake air temp 2°
- Intake air temp Hz
- So multiple values can be created over a single wire by creating a pulse signal reducing the number of wires required for reporting these values



129

SENT Data

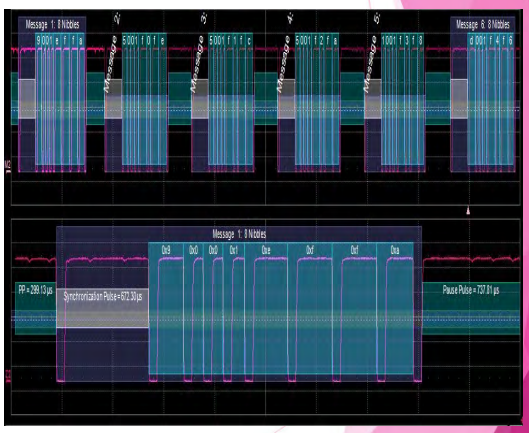
- What voltage at the highlighted circuit?
- How can it report multiple sensor information?
- This sensor uses SENT technology
- SENT requires a 5 volt supply, ground and SENT signal line 0-5 volts



130

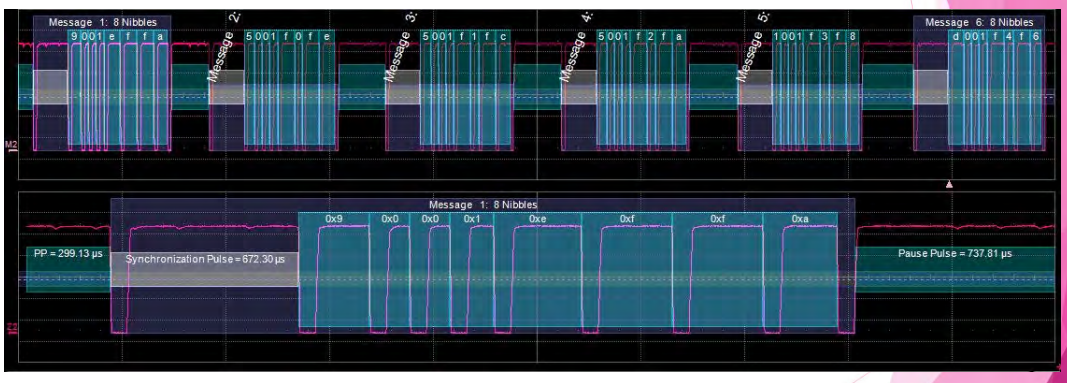
SENT Data

- SENT is Single Edge Nibble Transmission
- 0-5 V signal
- Measures the falling edge of each “pulse”
- The distance between falling edges represents a 4-bit data “nibble”
- The standard time unit is a tick
- A tick can represent 3-90 micro seconds (µS)
- Each data message starts with a calibration pulse, then the message and then the checksum nibble



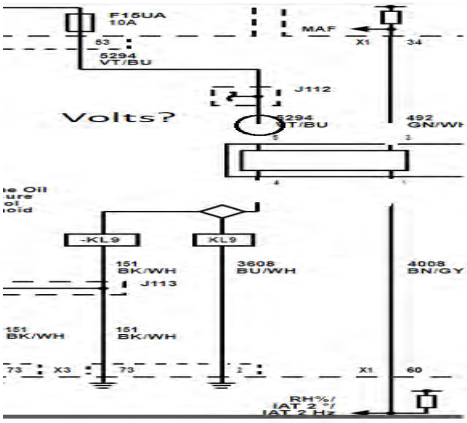
131

SENT Message



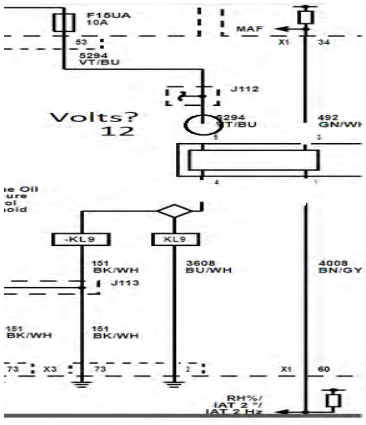
132

Lets test the sensor unplugged



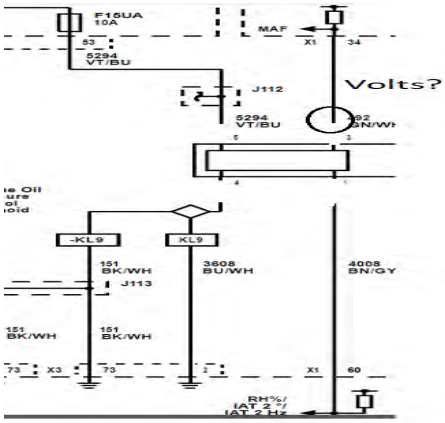
133

Test unplugged pin 5 battery volts



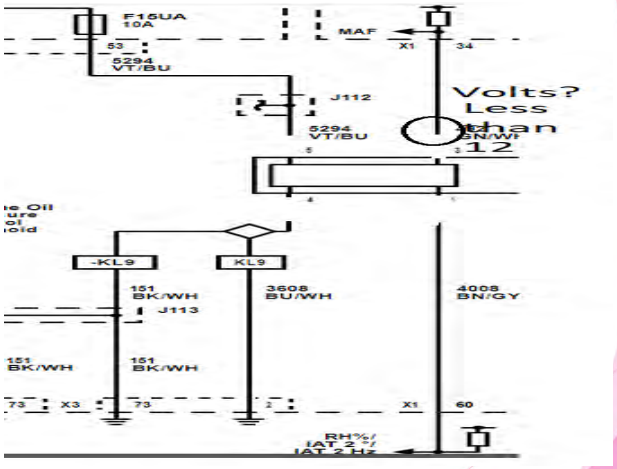
134

Continue unplugged pin 3



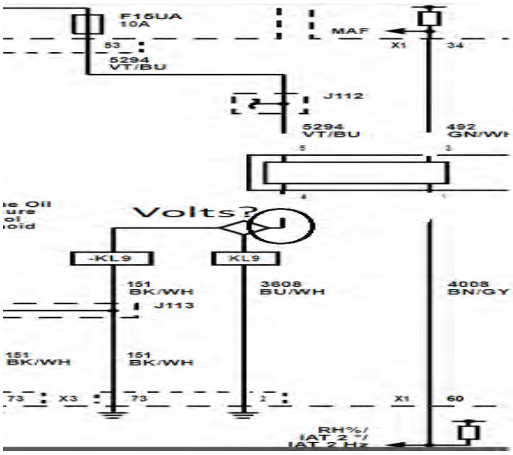
135

Pin 3 less than 12 volts why?



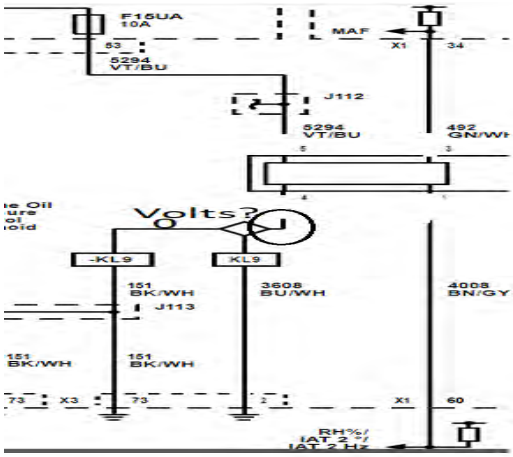
136

Volts pin 4?



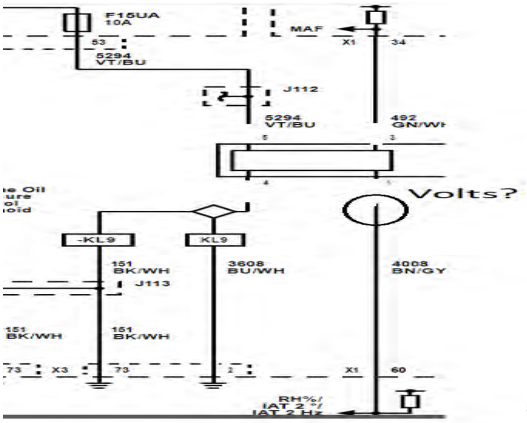
137

Pin 4 ground 0 volts



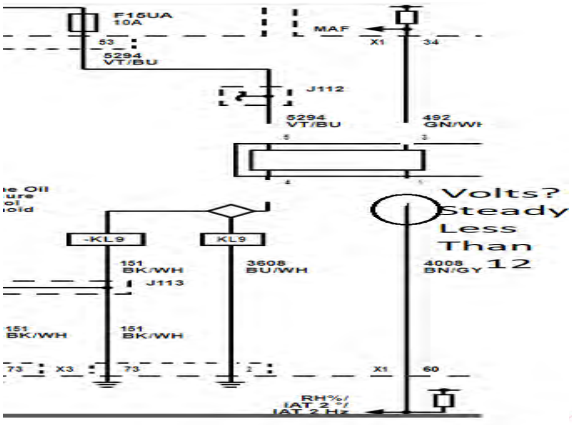
138

Pin 1 volts?



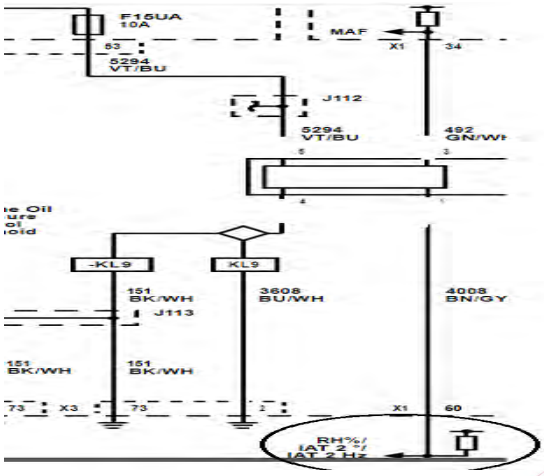
139

Steady less than 12 volts?



140

What is all this stating?



141

Tooling for successful communication diagnosis

- DSO Digital Storage Oscilloscope capable of capturing signals up to 10gbps
- J1962 Breakout Box
- DMM
- Terminal Assortment
- Attenuators
- Ethernet Signal Splitters
- Scan tools (Preferably OE)
- Service Information
- PC
- Patience

142

Tools

DSO

DMM

143

Tools

Terminal Kit

J1962 Breakout

144

Tools

Automotive DSO

Ethernet Signal Coupler

145

Case Study

- 2015 Jeep Grand Cherokee Diesel 4WD
- Multiple warning lamps on
- Some are flashing
- Does start and run most of the time, never stalls but may not crank sometimes
- Communication is sporadic
- Communication codes in most modules: radio, air bag, cluster, bcm, shifter, cruise control, drivetrain control, ABS, park assist, transmission
- Where do you want to start?
- Hold up!
- I just realized I recognize this truck!

146

Case Study

- I worked on this truck at a different shop a couple months ago
- Digging in mind history
- Was no start, no crank
- Several communication codes
- Could not communicate with the shifter, which was causing the no crank condition
- Checked fuses
- Many other modules have codes for lack of communication with the shifter and TCM and a couple other modules not related to the no crank

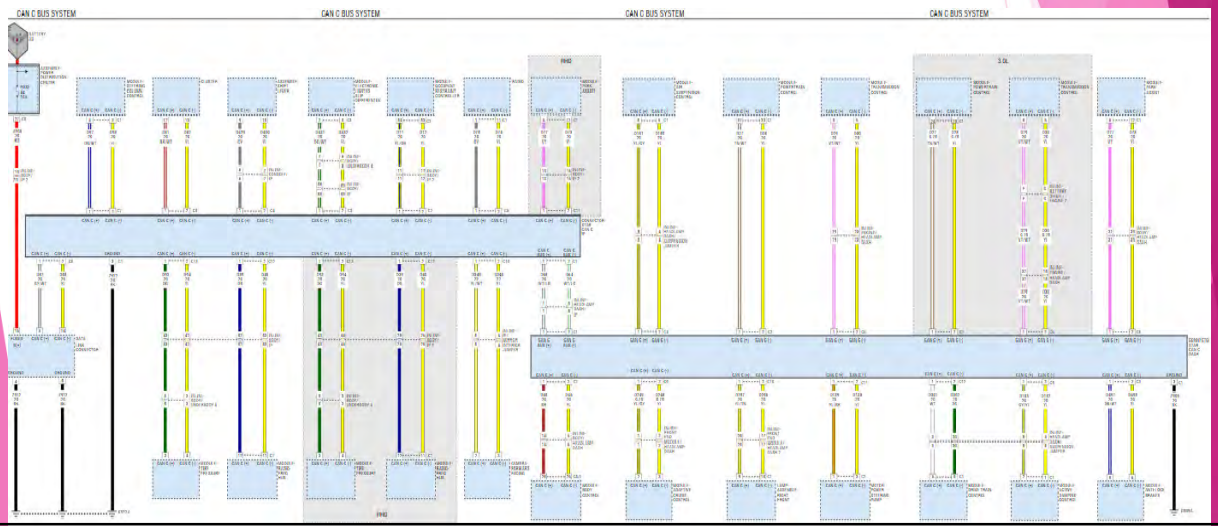
147

First Visit Case Study

- Search data
- Find communication circuit
- Shifter is on can bus C
- Can bus C includes of these modules
- All of the communication codes are in modules on Can C
- What is the first step?

148

Can Bus C



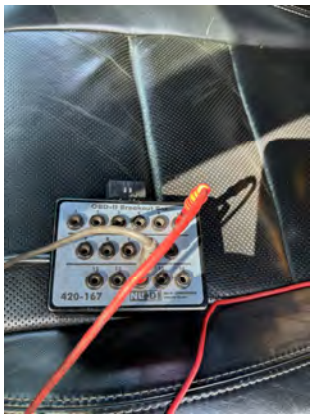
149

Can Bus C IP Star

- Typical Can Bus
- Modules connected through 2 junction points (Star Connectors)
- There are 2 connectors in the circuit
- One in the left instrument cluster
- One in the right console side
- Shifter is on the IP connector
- Since it is a typical Can Bus then there are terminating resistors
- The Star connectors contain these resistors

150

Checking Bus Resistance



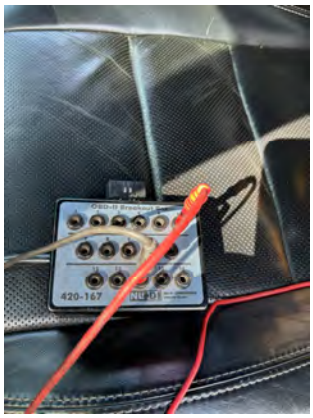
151

Can Bus C Star

- Connector is accessed for testing
- Can test all the comm circuits for the modules here
- Found after disturbing this connector some chimes went off and the resistance is now in specifications
- Push start button and now it runs

152

Resistance OK Now



153

Issue Returns

- Wiggle the instrument Star connector and the resistance again is out of specifications
- Again it will not start
- Watch the resistance while manipulating the IP star
- It continuously changes
- Instructed the customer to replace the star connector
- Call a few days later was told connector replaced and vehicle has left

154

Jeep Round 2 Fight

- Different shop calls a few months later
- Has a Jeep they need some electrical issues looked at
- Multiple warning lamps on, cluster and radio come and go cyclically
- May not start sometimes but most of the time it will
- Never stalls
- Will not go into gear
- They've had the Jeep for a few weeks

155

Jeep

- I pull up and it looks familiar but I can't put my finger on it
- Once I start it, I realize it is a diesel!
- Seriously how many black Jeep GC around with a diesel in them
- It has to be the same vehicle
- So now I start to remember what the issue was last time
- Problem#1 I assumed it was related to the previous issue

156

Same tests

- Scan all modules
- Communication codes in most modules on Can bus C: radio, air bag, cluster, bcm, shifter, cruise control, drivetrain control, ABS, park assist, transmission
- Where do you want to start?

157

Jeep

- Again check CAN bus C
- Resistance is within specs
- Because I had worked on it before, I remove dash panels and move the connector around again no change
- OK lets revisit the diagram for

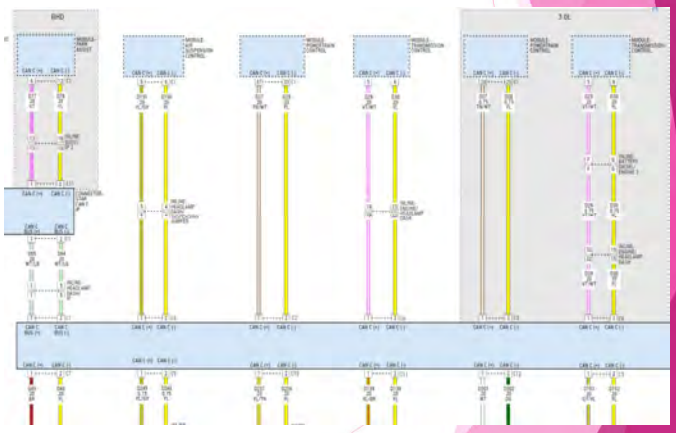
CAN C

- Where can we test these circuits?

158

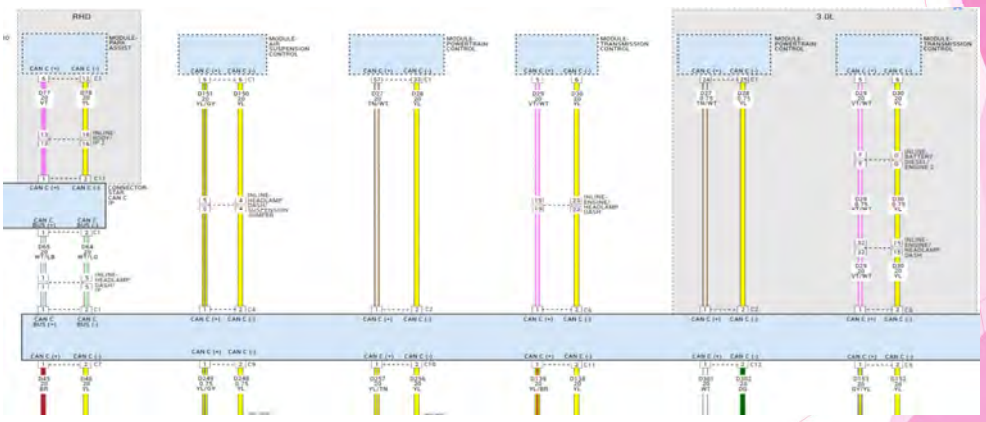
Star

- There are 2 connectors that tie all the modules together
- Resistance is OK at the DLC
- Many modules on the CAN C have communication issues and there are multiple systems inop
- I am still convinced it is similar to the previous issue



159

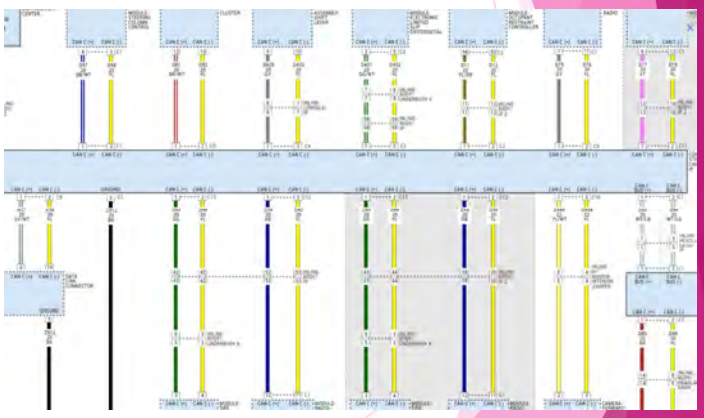
Can C



160

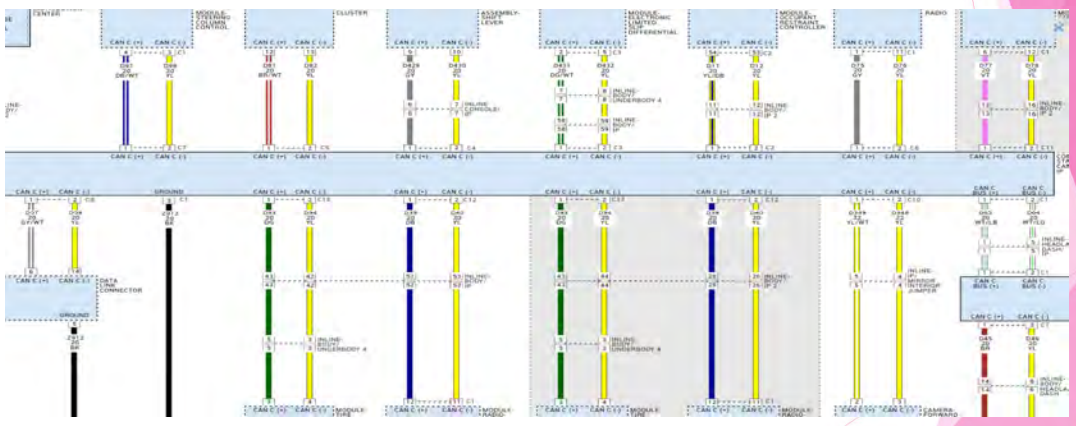
Jeep Comm

- So based on previous issues with this vehicle I access the other Star connector in the lower right side dash
- I move that connector around
- Nothing changes
- Check CAN resistance while moving the connector
- Still 58 ohms
- It is not an issue with a connector
- Furthermore I think it is not a physical layer issue because the resistance is OK



161

Can C Star 2



162

Next steps?

- Likely the issue is not physical
- Now what?
- What can we do?
- Disconnect modules?
- Remove fuses?
- Measure voltage?
- Scope CAN Bus?

163

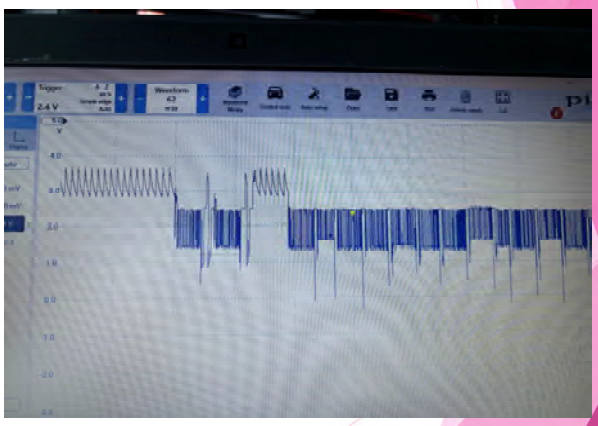
Next steps?

- Lets scope the Bus that is acting up
- Pins 6/14 on the DLC connects to all of these modules
- Before we hook up the scope what should we see?
- CAN high should be ?
- CAN lo should be?
- Ok lets hook up the DSO

164

Scope connected

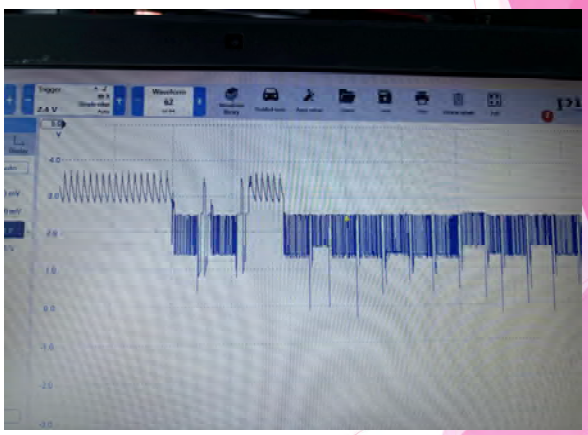
- Only CAN Lo is connected
- Do we need to connect to CAN Hi at this point?
- Maybe we could but I think I already see the problem
- What is going on here?
- This is Can Lo
- It should go 2.5-1.5 volts



165

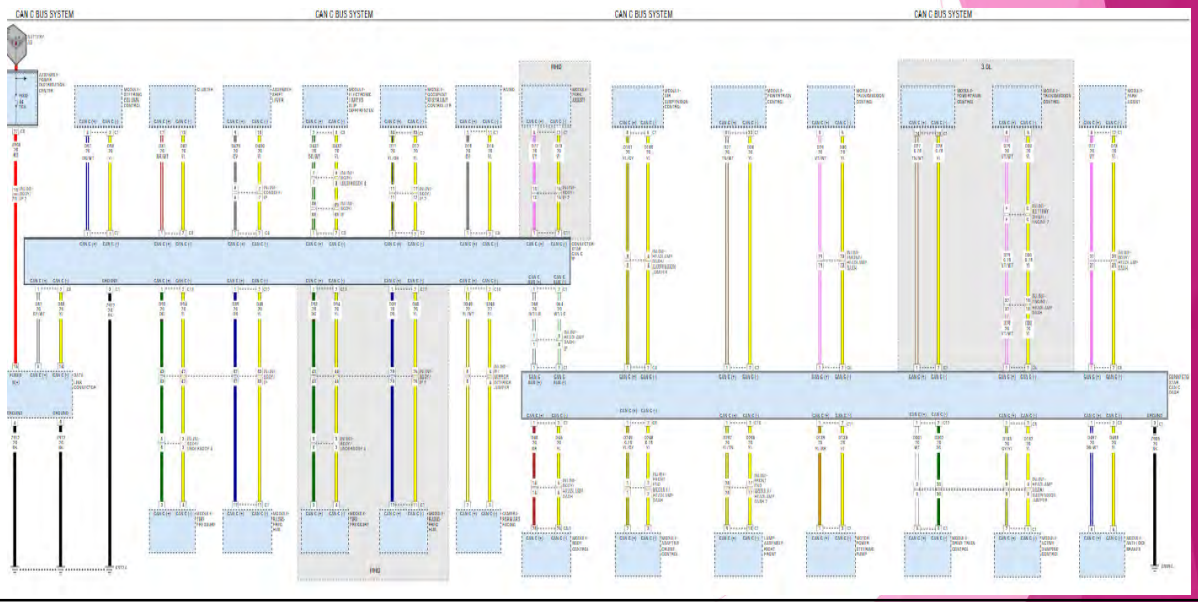
Issue?

- Can Lo 2.5-1.5
- Some dips below 1.5 concerned?
- A portion of the pattern is at 3 volts and travels to 3.5 volts
- What could be the cause of that?
- Short to voltage?
- Failed module?
- It looks like one module is causing this issue
- How can we locate which module?
- Again it does not look like a physical layer issue because it is not constant



166

Locate the module



167

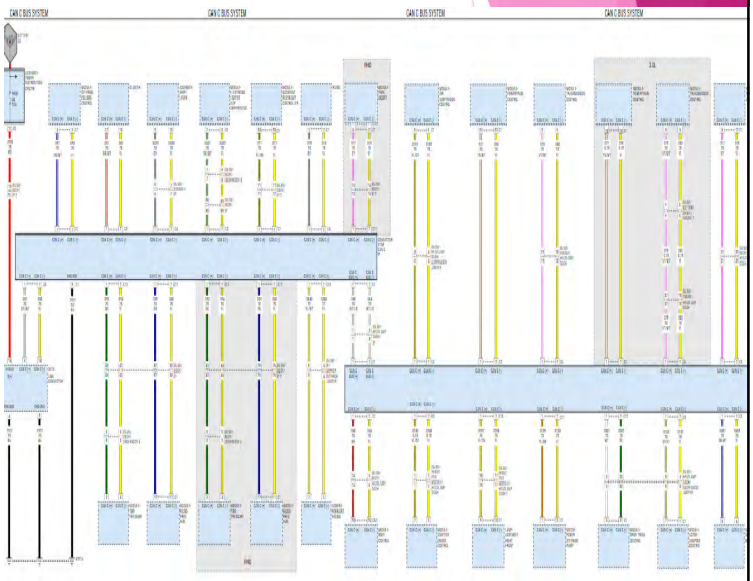
Circuit

- There is a lot of modules on this circuit
- What can we do?

168

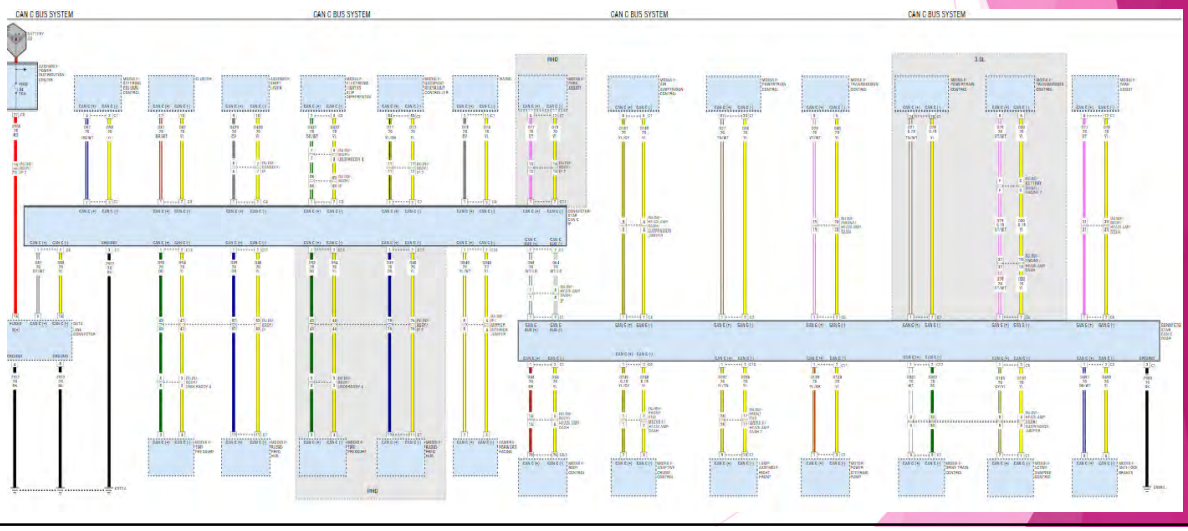
Circuit

- There is a lot of modules on this circuit
- What can we do?
- I choose to keep the scope and watch that odd pattern that keeps repeating itself
- Lets attempt to split the circuit
- Unplug the connector on the right while watching the scope pattern
- When the right connector is unplugged the pattern looks normal!
- So the concern is on some module on the right side
- Now what?



169

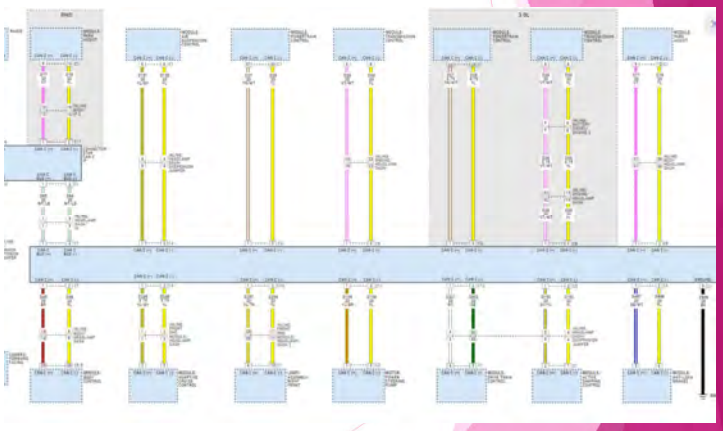
Problem is on the right side



170

Module Decipher?

- Modules on the right star connector:
- Air Susp
- Trans
- Engine
- Park assist
- BCM
- Adaptive Cruise control
- Right headlight
- 4WD module
- Dampening control
- ABS
- So do we need to remove fuses, maybe manually disconnect each module by accessing it?



171

Finding the Culprit

- The right connector is reattached
- The poor pattern returns
- Unplug each module at the right connector until something changes
- When C10 is unplugged the vehicle starts to act normal and the scope pattern starts to look normal
- C10 feeds RF headlight
- Plug C10 back in
- Problem returns

172

Finding the Culprit

- Plug C10 back in
- Problem returns
- Go unplug the headlight and problem is still there!
- Now what? Is it wiring?
- Unplug C10 problem goes away
- Plug C10 back in, issue returns
- Chase wiring now what?
- Unplug just the headlight still has issue
- When C10 is unplugged the headlight continues to operate so clearly C10 is not attached to that component

173

Finding the Culprit

- Unplug C10
- Clear all the codes
- Multiple modules have loss of communication with adaptive cruise control module codes
- So C10 is probably connected to adaptive cruise control
- What is the adaptive cruise control module? Where is the ACC module?

174

Adaptive Cruise Control

The optional equipment ACC+ system includes the following major components, which are described in further detail elsewhere in this service information:

- **Adaptive Speed Control Module** - An Adaptive Cruise Control (ACC) module (also known as the Adaptive Cruise Control/ACC sensor or radar sensor or module) is located on a bracket secured near the center of the underside of the front bumper support member of the Front End Module (FEM) behind the front fascia (Refer to 08 - Electrical/8E - Electronic Control Modules/MODULE, Adaptive Cruise Control/Description) .
- **Antilock Brake System Module** - An Antilock Brake System Module (ABS) (also known as Controller Antilock Brake/CAB or the Electronic Stability Control/ESC module) is located on the antilock brake Hydraulic Control Unit (HCU) in the engine compartment (Refer to 08 - Electrical/8E - Electronic Control Modules/MODULE, Anti-Lock Brake System - Description) .
- **Brake Lamp Sensor** - The brake (also known as stop) lamp sensor is located on the brake pedal support bracket under the driver side of the instrument panel (Refer to 08 - Electrical/Lamps/Lighting - Exterior/SENSOR, Stop Lamp/Description) .
- **ElectroMechanical Instrument Cluster** - A CRUISE indicator is located in the fixed segment display of the ElectroMechanical Instrument Cluster (EMIC) (also known as the Cab Compartment Node/CCN) that provides an indication to the vehicle operator when the speed control system is turned ON (Refer to 08 - Electrical/8J - Instrument Cluster - Description) .
- **Electronic Vehicle Information Center** - The Electronic Vehicle Information Center (EVIC) is located in the ElectroMechanical Instrument Cluster (EMIC) (also known as the Cab Compartment Node/CCN) and provides an interface to the vehicle operator for setting the adaptive speed control customer preferences as well as a display of the adaptive speed control and Forward Collision Warning (FCW) system status messages (Refer to 08 - Electrical/8M - Message Systems/Message Center/CENTER, Electronic Vehicle Information - Description) .
- **Forward Facing Camera** - The Forward Facing Camera (FFC) is located inside the Combined Rear View Mirror Module (CRVMM) housing assembly. The FFC provides input for data fusion purposes allowing the ACC sensor radar data to be redundancy checked (Refer to 08 - Electrical/8E - Electronic Control Modules/MODULE, Forward Facing Camera/Description) .
- **Powertrain Control Module** - The Powertrain Control Module (PCM) located in the right front corner of the engine compartment contains the software and hardware that monitors all of the speed control system inputs and controls all of the speed control system outputs (Refer to 08 - Electrical/8E - Electronic Control Modules/MODULE, Powertrain Control - Description) .
- **Speed Control Switches** - A speed control switch pod containing six momentary switch push buttons is located in the right horizontal spoke of the steering wheel (Refer to 08 - Electrical/8P - Speed Control/SWITCH, Speed Control/Description) .
- **Steering Column Control Module** - A Steering Column Control Module (SCCM) microcontroller is integral to the SCCM located at the top of the steering column just below the steering wheel (Refer to 08 - Electrical/8E - Electronic Control Modules/MODULE, Steering Column Control/Description) .
- **Wheel Speed Sensors** - A wheel speed sensor is located on the knuckle of each front and rear wheel (Refer to 05 - Brakes/Electrical/SENSOR, Wheel Speed - Description)

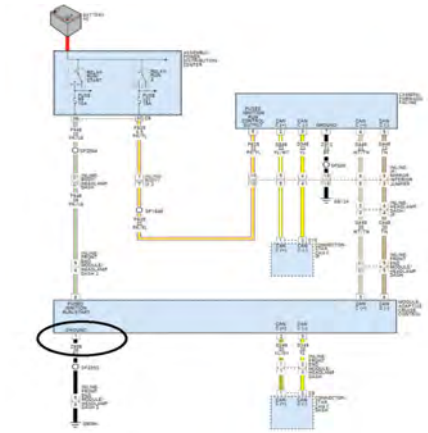
175

ACC Module

- OK now we know the ACC module is the Radar unit in the front of the vehicle
- Access the Radar
- Find corrosion in the Radar connector
- Corrosion is on the ground pin!

176

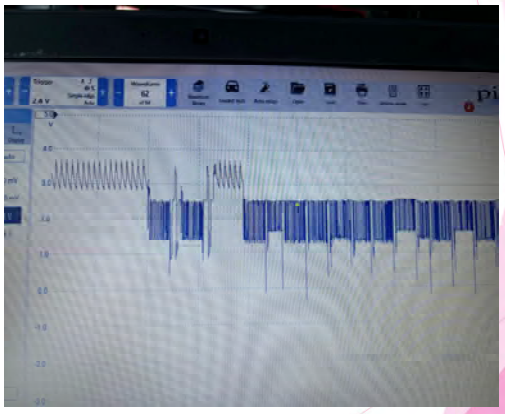
Diagnosis



177

Final

- Pin 1 of the Adaptive Cruise Control Module (Radar) is the module ground
- The connector was found corroded and the ground was compromised
- The loss of ground caused the module to lose the ability to pull Can Lo circuit low, resulted in the Can Lo circuit to travel high when the Can chip turned on in the ACC module
- This rise in voltage tied up the bus causing all of the listed issues
- Left Radar unplugged and all OK
- Recommended new Radar and connector



178

Case Study 2013 Chevrolet Malibu

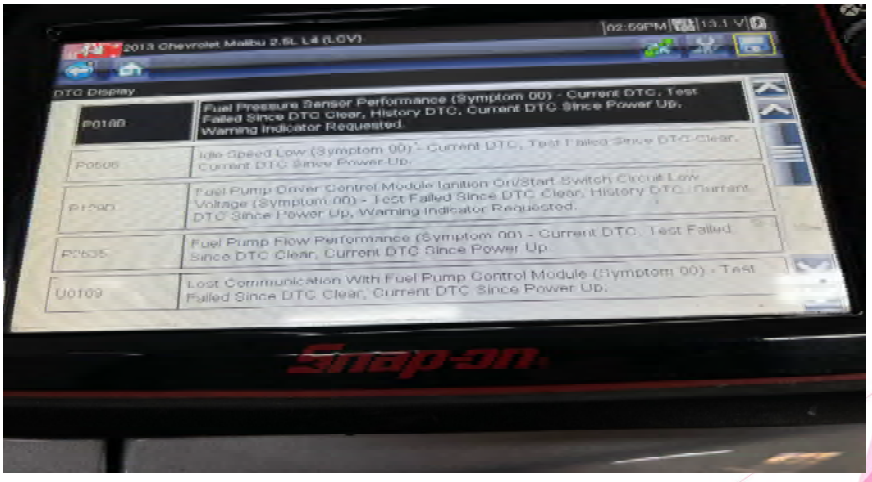
179

2013 Malibu CEL on

- Customer states it has codes for loss of communication with the Fuel Pump control Module
- He is pretty sure it needs a new module but wants me to verify for him
- 2.5 L non-hybrid car
- Vehicle does start and run normal
- What's your first step?

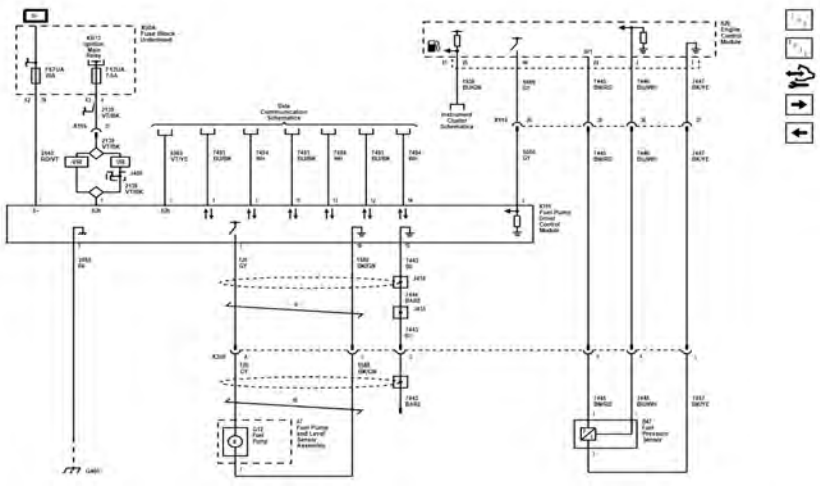
180

Research Verify



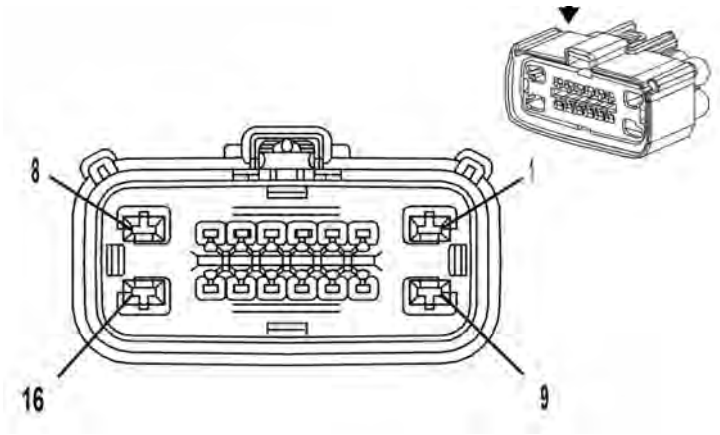
181

Research Find the Diagram



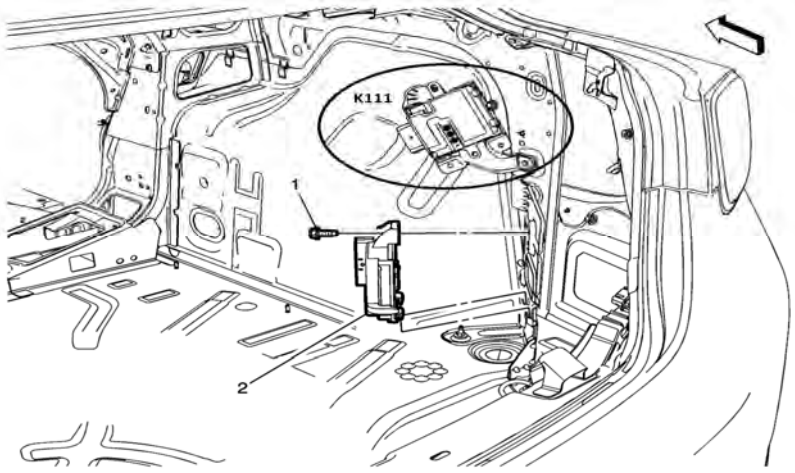
182

Research



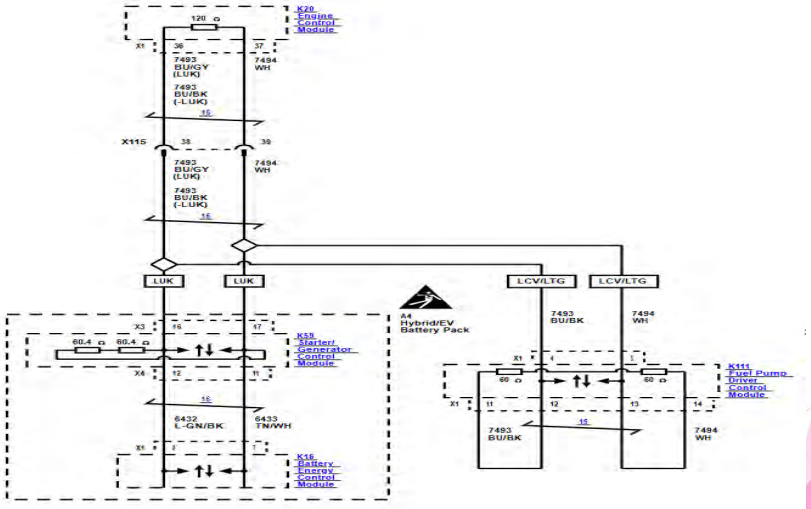
183

Research



184

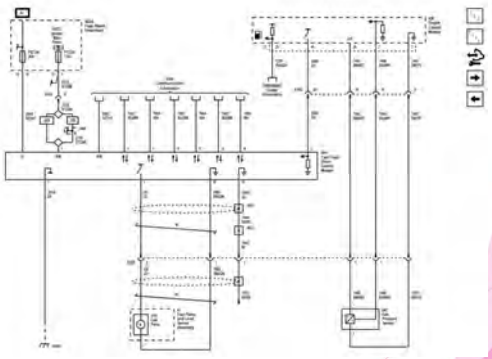
Research



185

Testing

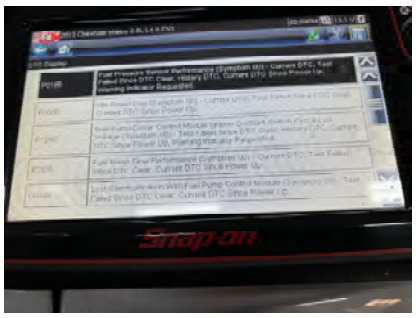
- Research was performed to discover the operation of the fuel pump module
- Wiring diagram located and deciphered
- Component location found it is in the right rear trunk
- Fuses found
- TSBs checked



186

Codes

- Many codes exist
- Customer may have set some
- All codes are cleared
- Loss of communication with fuel pump control module code sets immediately after clearing and light returns after 2 key cycles
- Issue is duplicated now what?



187

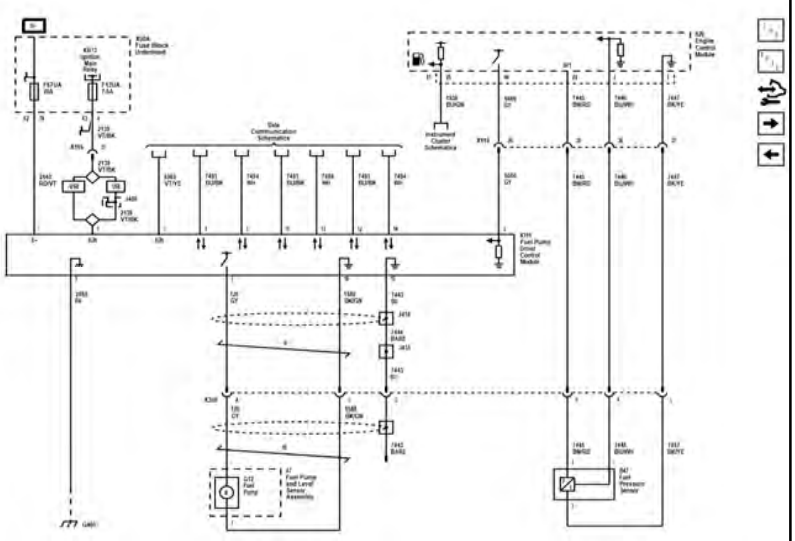
Testing

- Customer already has trunk panel accessible
- The silver box is the FPCM
- What is needed for successful communication?
- _____, _____, _____
- How do we test for those?

188

Testing circuits

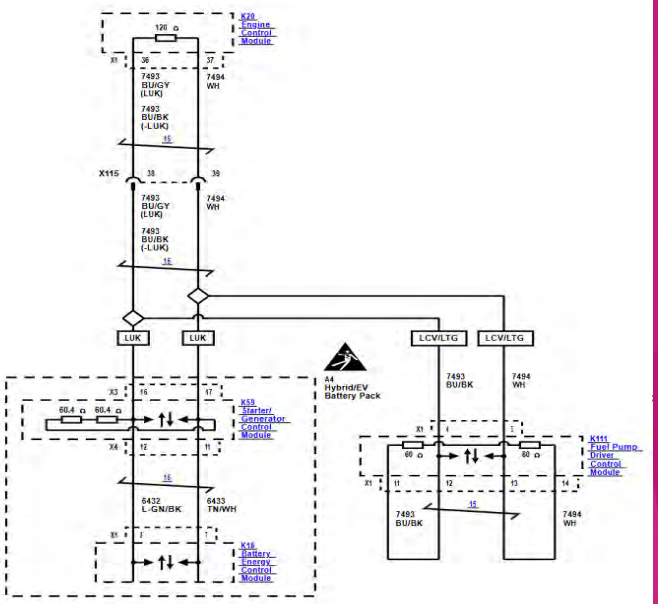
- At the FPCM
- Power on Pin 1 is verified
- Ignition power pin 6 is verified
- Ground on Pin 9 is verified
- What else do we need to test
- What is Pin 2?
- How do we test the communication lines?
- Comm is on terminals 4,5,11,13,12,14 but where do they go?
- What is Pin 7?
- We need to go to a communication diagram now



189

Testing Comm circuits

- Using a communication diagram for the FPCM we see the route of comm.
- This car is not a hybrid so the A4 battery is non-existent
- Pins 11,12 13,14 just leave the module and lop around for terminating resistance purposes
- Pins 4,5 have a direct route to the PCM only it is a dedicated bus
- How would you test that circuit?

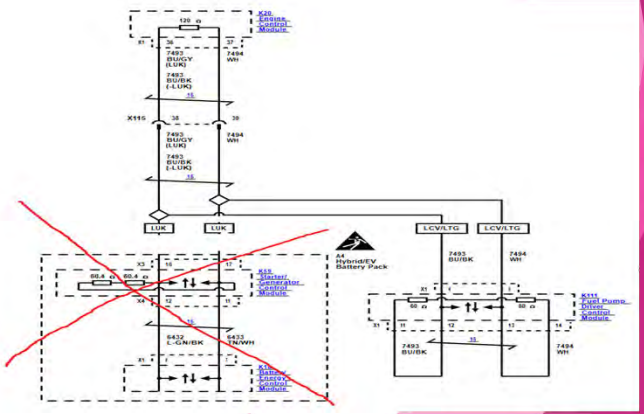


190

Test Resistance across pins 4,5 at FPCM
If all OK then we should see 120Ω

FPCM Connector

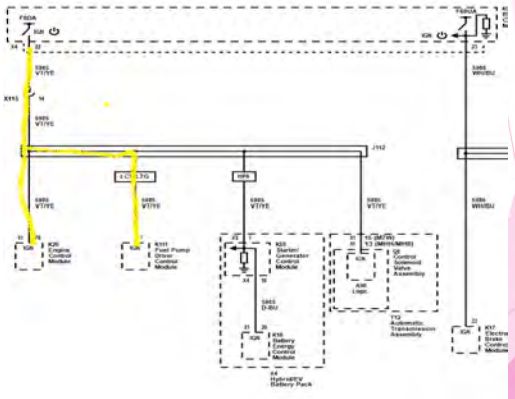
Diagram FPCM to ECM



191

Pin 7?

- Remember the Pin 7 at the FPCM
- That receives a 12 volt wake up circuit enable from the BCM
- Is it important to module communication?
- Yes if the voltage is not present then the module will not wake up
- Test Pin 7 at the FPCM has 12 volts OK



192

Recap

- All the power and grounds at the FPCM module are tested and verified OK
- Measure communication resistance from FPCM to the ECM 119Ω
- Measured resistance form comm lines to ground OK
- Verified communication enable circuit is active
- Turn on circuit ECM to FPCM is OK
- Anything left to check?
- What is bad?

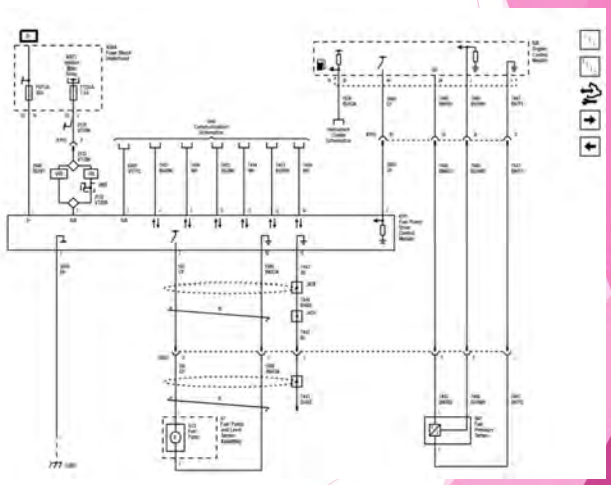
193

Round 2 Malibu

194

Now what?

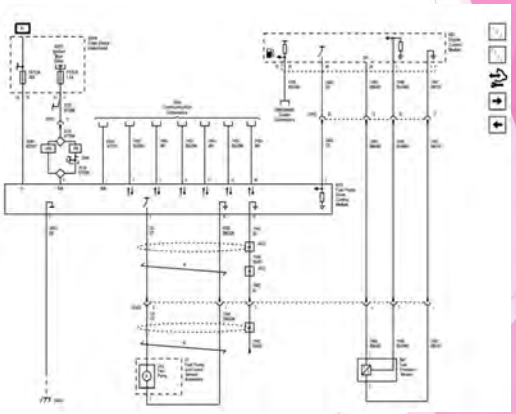
- 3 days later customer calls, same issue
- How can that be?
- Oh wait maybe it needs programming
- Tried programming it
- No communication scan tool to FPCM
- How can that be?
- What to test next?



195

Recheck

- Recheck all power and grounds
- Check module wake-up circuit OK
- Check module on command from ECM OK
- Recheck communication circuit resistance from the FPCM to ECM
- Check FPCM communication lines to ground resistance OK
- Physically this is all OK!

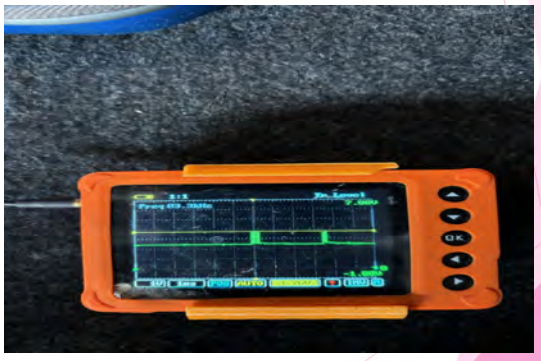


196

Scope communication circuits

Back probe connector with modules connected

Found a normal looking can High circuit same for Can low



197

Scope Communication lines

- Remember only 2 modules on this circuit
- Can Hi and Lo look normal
- What should the voltages be?
- I start to wonder which module is communicating. The ECM? FPCM? Both?
- How can I tell?

198

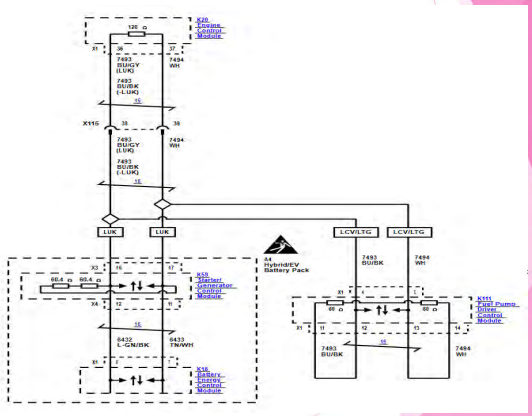
Scope Can

- I am back probed at the FPCM
- Trying to see if both modules are talking or just one
- So I unplug the FPCM and monitor the Bus
- It immediately becomes very busy
- Why?
- So this indicates to me that the physical layer between the ECM and FPCM is OK because the ECM just realized the FPCM went offline
- Good indicator that both modules are talking

199

Now what?

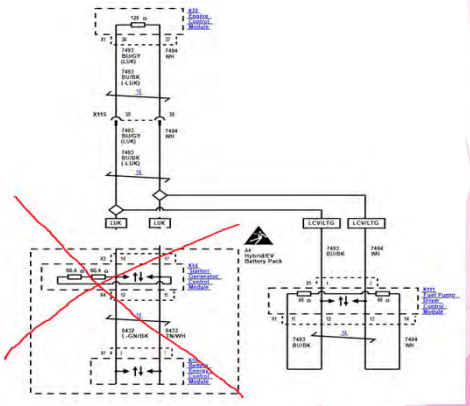
- What if the diagram is wrong and there is another module talking on the Bus too?
- How to tell that?
- So while the scope is connected to the FPCM and the FPCM is unplugged there is still active communication
- So the ECM is unplugged and now communication stops
- That proves to me there is only the ECM and FPCM on this circuit



200

Make another call

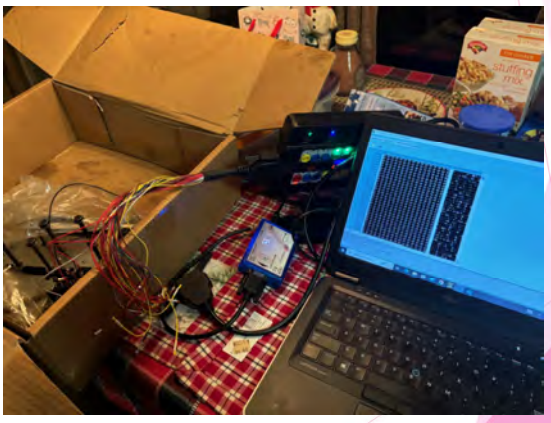
- The FPCM power and grounds are good
- There is only the ECM and FPCM on the comm circuits
- The communication looks correct
- So I think either the new FPCM is defective (Ugh)
- Or the ECM has lost its mind
- I decide to leave (shoulda just bailed permanently)
- I call the junkyard order a used ECM and a FPCM for good luck



201

Return Visit

- Parts show up
- I bench clone the ECM
- Go to reinstall both parts
- Try the PCM first
- No Bueno
- Code returns immediately
- Try the used FPCM
- You already know the result of that
- Now what?



202

Incorrect Info?

- Maybe I am working with the wrong system?
- I unplug the control module
- Car eventually stalls
- This is definitely the FPCM (silver box)
- I revisit service info
- The previous diagrams are cut and dry
- The fuel pump circuits are in the powertrain controls: fuel pump circuits
- The communication circuits is under expansion busses chassis
- I start to look in the rest of the communication circuits out of desperation

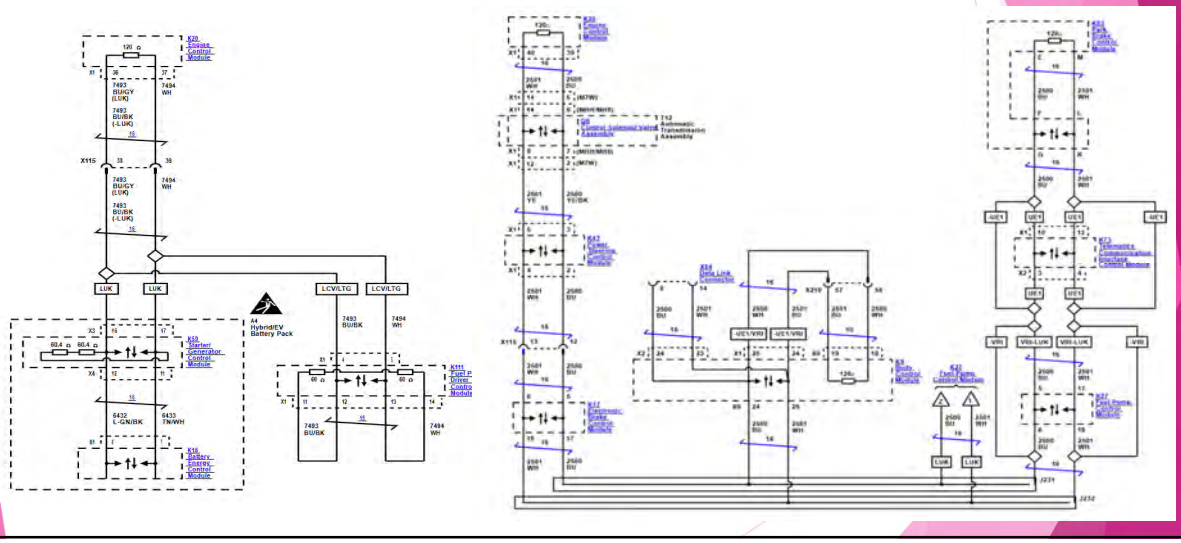
203

Incorrect Info?

- I see this other module under the silver one I am working with
- It has me wondering what it is
- So I unplug it
- Now the parking brake light is on and there is no comm with parking brake
- Some weird clicking that was occurring in the left rear wheel well also stops
- I start to think this is the parking brake control module (Maybe)
- I ignore that module for now

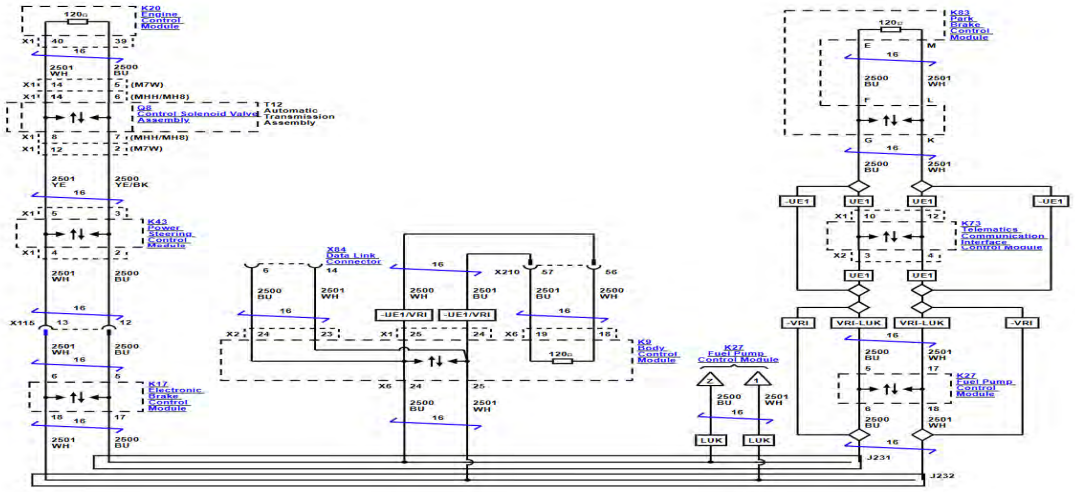
204

Rest of the comm circuits for engine controls are GM LAN HS



205

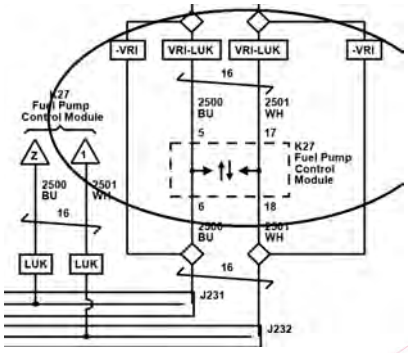
I see something odd in the other diagram



206

I see something odd in the other diagram

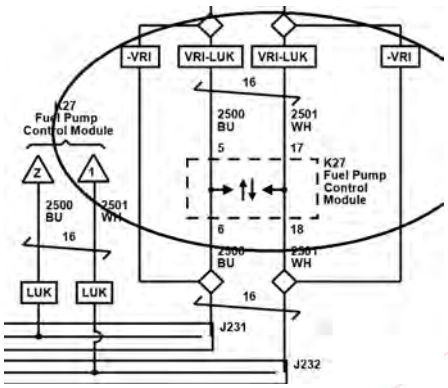
- There is another FPCM that is wired into HS Bus
- But it can not be the one I am working with because it would affect other modules if were unplugged
- I am looking at the option codes
- I do not have LUK that is hybrid
- I do have VRI
- I'm confused if VRI is actually going to that FPCM or not?



207

Another FPCM

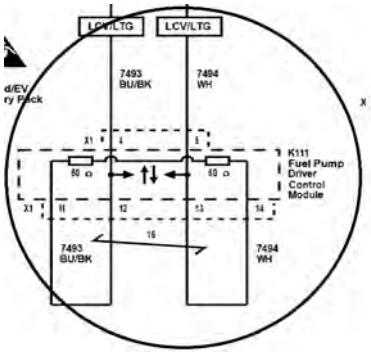
- Where is this module?
- What is it?
- Is it a waste of my time?
- This is IMPORTANT:
- Note the item ID code K27
- I want to do some research on this K27 FPCM



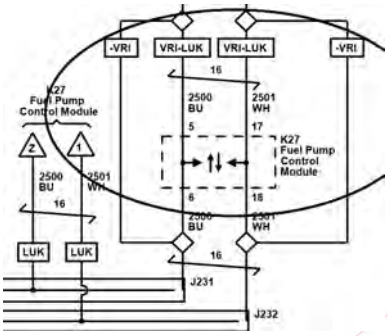
208

Is there really 2 FPCM? If so where is the other one? What does it do?

FPCM K111 with LCV/LTG



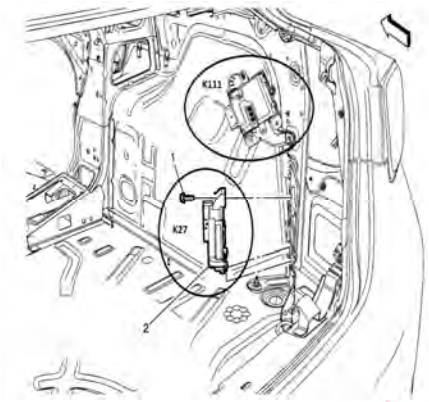
FPCM K27 with VRI



209

Service Info Indicates locations

- FPCM K111 causes the engine to stall when unplugged
- The module under it is supposed to be K27 FPCM but when I unplug that one the engine does not stall but the parking brake warning light is on?
- If this other module is really a K27 what is it for?
- I take the part number off the module and look it up
- A generic search indicates it is a FPCM for many GM vehicles!!!!

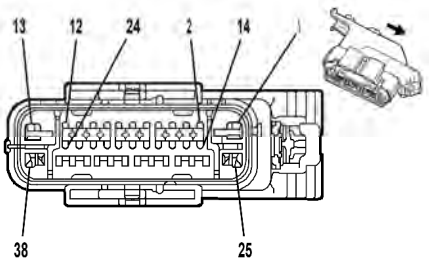


210

There is fuel pump circuits in the connector for K27 but it does not shut off the vehicle when disconnected

K27 Fuel Pump Control Module (VR1)

Pin	Size	Color	Circuit	Function
1	2.5 1	RD/GN RD/VT	1140 1640	Battery Positive Voltage Battery Positive Voltage
2	-	-	-	Not Occupied
3	0.35	GY/BK	1427	Shutter Valve Solenoid Control
4	-	-	-	Not Occupied
5	0.5	BU	2560	High-Speed GMLAN Serial Data (+) (2)
6	0.5	BU	2559	High-Speed GMLAN Serial Data (+) (2)
7	-	-	-	Not Occupied
8	0.35	WH/BU	1866	Serial Data Communication Enable
9	-	-	-	Not Occupied
10	0.35	BU/WH	1446	Fuel Line Pressure Sensor Signal
11	-	-	-	Not Occupied
12	0.35	GY/BK	1427	Shutter Valve Solenoid Control
13	2.5	GY	120	Fuel Pump Supply Voltage
14+15	-	-	-	Not Occupied
17	0.5	WH	2561	High-Speed GMLAN Serial Data (+) (2)
18	0.5	WH	2561	High-Speed GMLAN Serial Data (-) (2)
19	-	-	-	Not Occupied
20	0.35	DB/GY	465	Fuel Pump Primary Relay Control
21	0.5 0.35	VT/BK VT/BU	339 2179	Run/Crank Ignition 1 Voltage Run/Crank Ignition 1 Voltage
22	-	-	-	Fuel Line Pressure Sensor 5V



211

What does K27 do for the fuel system?

- I read an aftermarket info system end to end trying to find info on K27
- Aftermarket indicates it is a FPCM and controls fuel flow
- So I go to factory SI
- Still same info
- I go to module programming in factory SI and I read this:
- Are you kidding me? The friggin K27 FPCM only controls the active grill shutter if it not equipped with certain options, and the geniuses decided to mount it all the way back in the trunk!!!

K27	Fuel Pump Flow Control Module Scan Tool Information	Engine Controls Schematics - 2.2L or 2.4L engine or Active Grille Air Shutter Schematics (For this vehicle with the 2.0L (LTG) or 2.5L (LCV) engine, the fuel pump flow control module controls the active grille air shutter only)	Fuel Pump Flow Control Module Replacement - 2.2L or 2.4L engine or Fuel Pump Flow Control Module Replacement - 2.0L (LTG) or 2.5L (LCV) engine	Fuel Pump Control Module Programming and Setup

212

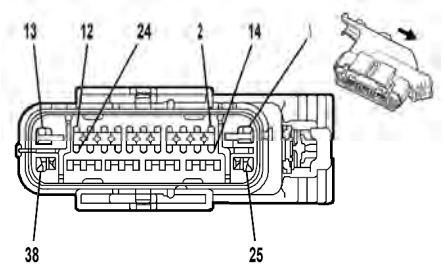
What does K27 do for the fuel system?

- So K27 part number comes back as a FPCM
- It does not control fuel it only controls the grille shutter on my vehicle
- So what are the chances the engineers still allow this module to be called a FPCM by the other modules?
- If the car does or does not use this K27 as the actual FPCM it is still called the FPCM!!!
- So likely the issue is with this module
- Now what?

K27	Fuel Pump Flow Control Module Scan Tool Information	Engine Controls Schematics - 2.2L or 2.4L engine or Active Grille Air Shutter Schematics (For this vehicle with the 2.0L (LTG) or 2.5L (LCV) engine, the fuel pump flow control module controls the active grille air shutter only)	Fuel Pump Flow Control Module Replacement - 2.2L or 2.4L engine or Fuel Pump Flow Control Module Replacement - 2.0L (LTG) or 2.5L (LCV) engine	Fuel Pump Control Module Programming and Setup

213

Test circuits at K27



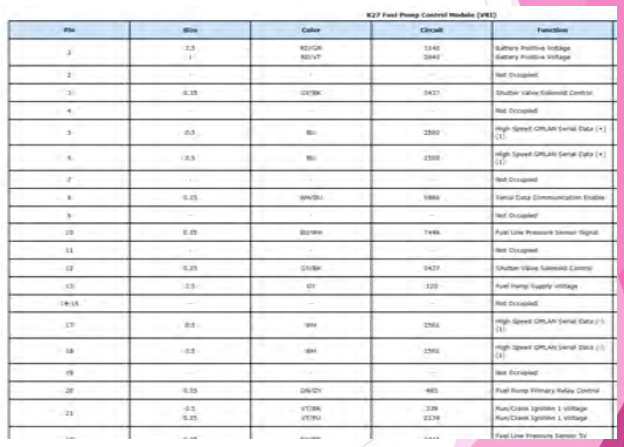
K27 Fuel Pump Control Module (VEC)

Pin	Wire	Color	Circuit	Function
1	2.5 1	RD/GN RD/VT	1142 2642	Battery Positive Voltage Battery Positive Voltage
2	-	-	-	Not Occupied
3	0.35	GY/BK	5427	Shutter Valve Solenoid Control
4	-	-	-	Not Occupied
5	0.5	BU	2550	High Speed GMLAN Serial Data (+) (2)
6	0.5	BU	2551	High Speed GMLAN Serial Data (+) (2)
7	-	-	-	Not Occupied
8	0.35	WH/BU	5966	Serial Data Communication Enable
9	-	-	-	Not Occupied
10	0.35	BU/WH	7446	Fuel Line Pressure Sensor Signal
11	-	-	-	Not Occupied
12	0.35	GY/BK	5427	Shutter Valve Solenoid Control
13	2.5	GY	120	Fuel Pump Supply Voltage
14|15	-	-	-	Not Occupied
17	0.5	WH	2561	High Speed GMLAN Serial Data (-) (2)
18	0.5	WH	2561	High Speed GMLAN Serial Data (-) (2)
19	-	-	-	Not Occupied
20	0.35	GN/GY	465	Fuel Pump Primary Relay Control
21	0.5 0.35	VT/BK VT/YU	339 2170	Run/Crank Ignition 1 Voltage Run/Crank Ignition 1 Voltage
22	-	-	-	Fuel Line Pressure Sensor 5V

214

K27 testing

- Decide to check the K27 (FPCM or Active Shutter Module) as I think it can set FPCM comm codes because in some cars it is a FPCM, however it is not in my vehicle
- So we still need to test: _____, _____, _____
- I check all of the power circuits Ok
- I scope the comm lines OK
- I check the ground
- I check the ground!!!



215

Issue?

- I check the ground by removing the terminal cover and back probe, I like to test circuits connected and loaded
- There was not a voltage drop on the ground
- BUTTTTT when I remove my back probe pin the ground terminal comes with it!
- I cant push it back in!
- I remove the terminal side lock
- Push the ground pin back in, lock the side lock
- Reconnect it

216

Fix

- The ground was reinserted into the connector
- Codes cleared
- No more concerns
- Even that weird sporadic clicking noise in the left rear fender stopped!

217

Summary

- I made a few mistakes
- Called the module failed it was not
- Started chasing my tail rechecking things I already tested when it was not fixed with the new FPCM
- I trusted aftermarket service info that did not have that one sentence about K27
- I “tried” used components
- I have no idea how that terminal got out of the connector, it is double locked
- But I did fix the car. I wonder how long other shops that don’t attend training would have had this car? I bet it would have gotten scrapped.

218

Thank You!!!!

- I truly appreciate your time today!!!
- I hope you found the class beneficial and can use some of this information to make your life easier, and customers happy!
- Any follow up questions feel free to reach out by email: r.kenney@hvcc.edu
- Thanks to G, Doreen and the great staff at TST!!!

219