Gillig G6 Dinex Training

CLASS SOP'S

- Break times
- Lunch time
- End of class
- Questions are encouraged
- Handouts are provided, but please take notes!

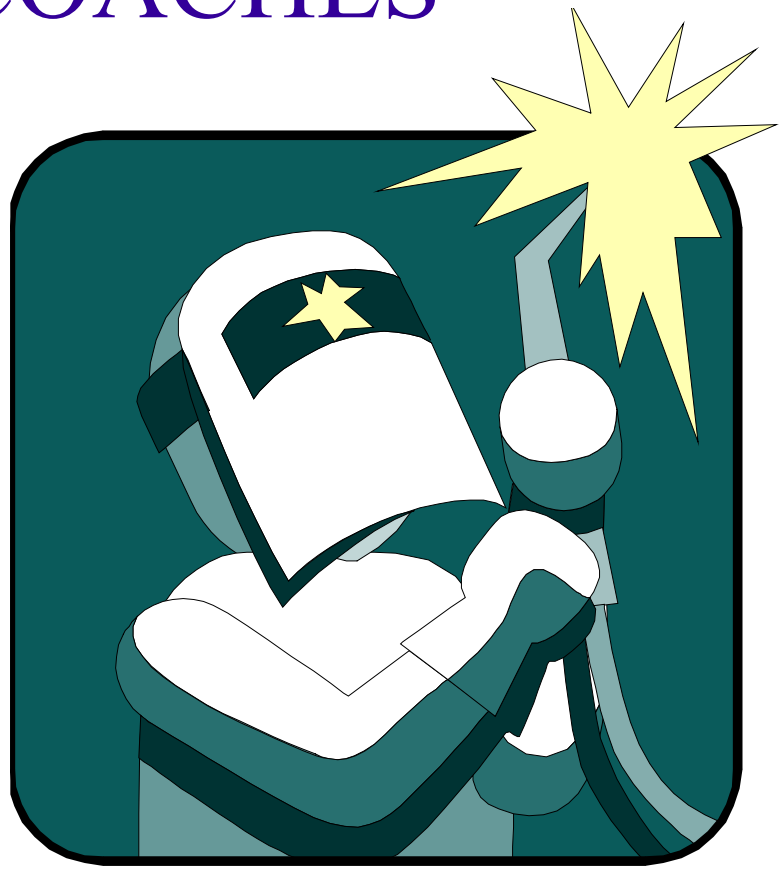
SAFETY

- Practice general safety procedures.
- Always wear safety glasses.
- Use test equipment properly.
- Use care when working around belt driven accessories.
- As batteries contain acid, the correct clothing should be worn when handling batteries.
- Care should be used dealing with electricity, as shocks can occur.

SAFETY PRECAUTIONS

FOR GILLIG COACHES

- Caution should be exercised when welding on the coach
- Main battery disconnect switch should be turned OFF
- All electronic system computers should be disconnected before any welding takes place on the vehicle



CLASS OBJECTIVE

Covered in Gillig G6 Multiplexing/Electrical:

- Identification, location and function of Multiplexing System components
- Familiarization of the Gillig electrical schematics
- J1939 communication
- Dinex system interface
- Safety precautions
- Troubleshooting techniques

G6 Multiplexing Terminology

- Data Bus – Type of network configuration where nodes are connected to a common communication cable through tee connectors. Bus refers to the exchange of information between computers.
- J1939 Protocol-The definition of language used for communication
- Terminating Resistor-A resistor used at the end of a twisted pair communication cable to stop/consume the electrical message.
- Node----------An individual functional module in the network. The telephone receiver in a network.
- ID---------- The unique address symbol (either a number or a character) which is assigned to each functional unit in the network. A telephone number.
- I/O---------- Inputs (sensors and switches) and Outputs (components or loads).
- CAN----------Stands for controller area network. The type of network configuration used for J1939 protocol.

G6 Multiplexing Terminology (cont'd)

- MBC----------The main bus controller in charge of the entire system.
- DIO----------An intelligent follower module.
- CNET----------The unique name for DINEX systems to be defined as DOWNLINK data port. Acting as controller function.
- Module--------The network functional unit which contains the intelligent co-processor unit. The vital communications data link to IO devices, inputs and outputs.
- Clean Power--(Computer Power) The isolated power source for modules in the network. "Clean Power" avoids data corruption from a common power source such as battery or electrical interference. Free from EMI and RFI
- LED----------A light emitting diode. A small semi-conductor lamp.
- Reset----------Restart the system.
- Cellnet --------The unique function of DINEX module. Each HCNC Controller module which has the capability to control another group of modules which might function as a slave or controller module.

G6 Multiplexing Terminology (cont'd)

- Multiplex------A method in which multiple digital signals are combined.
- Inputs----------Switches, sensors or controllers which supply signals in the form of voltage or ground, to provide information. The computer can make use of both "active" and "inactive" signals to perform a specific function.
- Data------------The information from module to module over Multiplex system network.
- Outputs--------The transistors in a module that act as a switch to turn components on/off. They are controlled by programming logic.
- Ring Loop-----Data bus structure in which the modules are connected to form a "ring".
- Ladder Charts-Ladder charts, circuits, or diagrams are logic diagrams. They are not schematics. The primary function of a ladder diagram is to show how devices related to one to the other.

MULTIPLEXING

Why We Cover It first

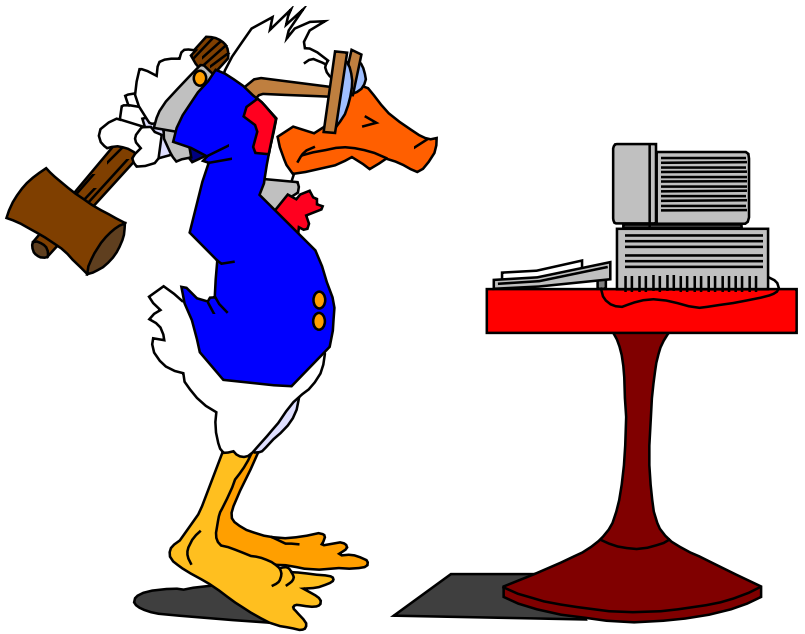
- Multiplexing is directly responsible for over 95% of Gillig circuits
- Virtually every Gillig circuit is associated with multiplex in some way
- Every coach manufactured by Gillig uses multiplex, since mid 1999 (including Phantoms) when we switched to I/O Controls (Dinex)
- First multiplexed Gillig bus was for Hertz in 1996, we built 250 units using the Allen Bradley system

Why Gillig Uses Multiplexing?

- Reliable way of interfacing multiple computer controlled systems to integrate safety features
- Ease of troubleshooting using LED's and ladder diagrams
- Reduced number of vehicle connections
- Designed to keep input and output wire lengths to a minimum
- Reduction of electrical components

What Is At The Heart of Multiplexing?

- The heart of the multiplexing system is a computer
- Fortunately, we get all the good things computers provide
- Unfortunately, we also get all the bad things



Wire Basics

Solid vs multi-strand.

- Solid used mostly in stationary applications
- Multi-strand used mostly in high vibration applications

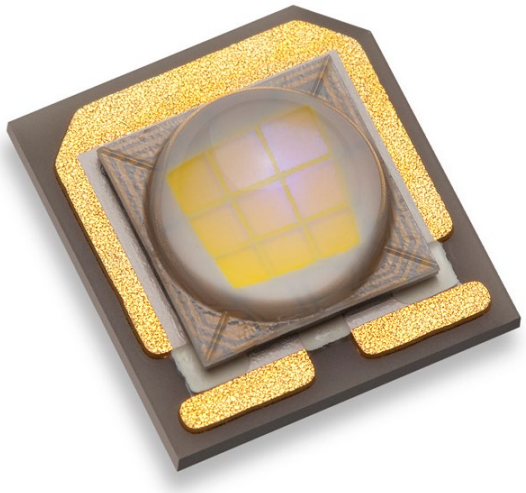
Primary wire – PVC insulated wire highly resistant to grease, oil and acids

- GPT – general wall thermoplastic wiring rated to 176°F
- TWP – lead free, thin walled pvc, rated to 221°F
- HDT- heavy duty thermoplastic, rated to 176°F

Cross linked – Insulated with a chemically cross linked polyethylene that provides improved resistance to heat deformation, abrasion, chemicals and stress cracking

- TXL – extra thin wall, for minimal weight and size, rated -59°F to 257°F
- GXL – thin wall, rated -59°F to 257°F
- SXL – regular wall, rated -59°F to 257°F

Why LED's Are Popular



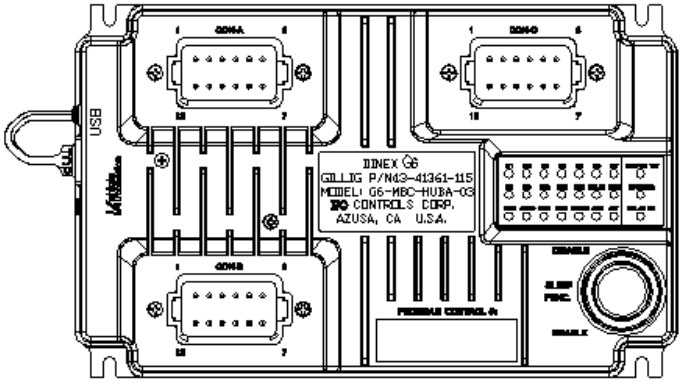
- LED’s use only 10 to 20 ma to illuminate
- 75% less energy than incandescent
- They generate very little heat
- Compact size
- Resistant to breakage
- Light projection is directional
- No mercury, more environmentally friendly
- 25 times longer life
- Inexpensive to manufacture
- Billions of dollars less in energy costs
- Incandescent – 90% energy lost as heat
- Fluorescent – 80% energy lost as heat

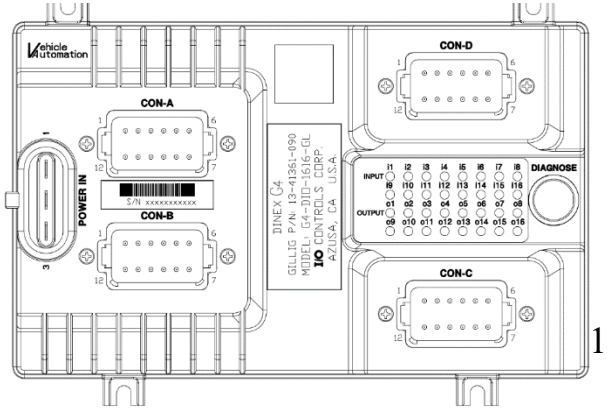
COACH MULTIPLEXING ZONE LAYOUT

- Dinex divides the coach into zones
- The zones start at “A” and proceed alphabetically
- The last zone on the coach is zone “D”
- Each zone contains a module or modules
- Modules in each zone control circuits close to that area
- All the zones are joined together to form a data loop

Multiplexing Components

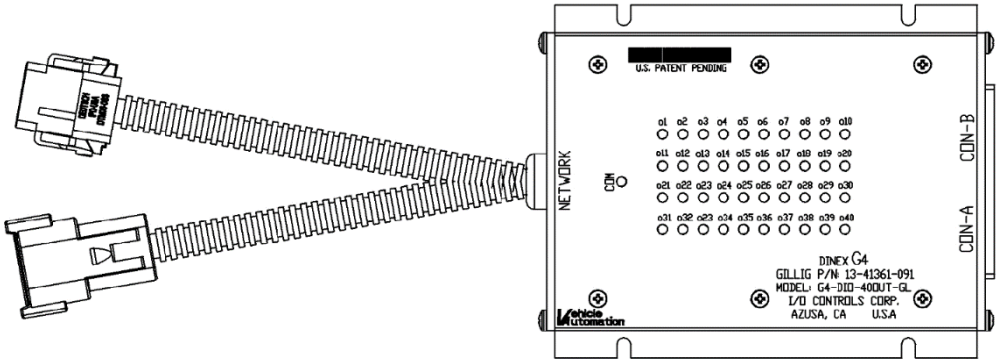
- Power Management Module (PMS). Built into the MBC
- Main Bus Controller (MBC)
- Digital Input and Output Controller (DIO 16/16)

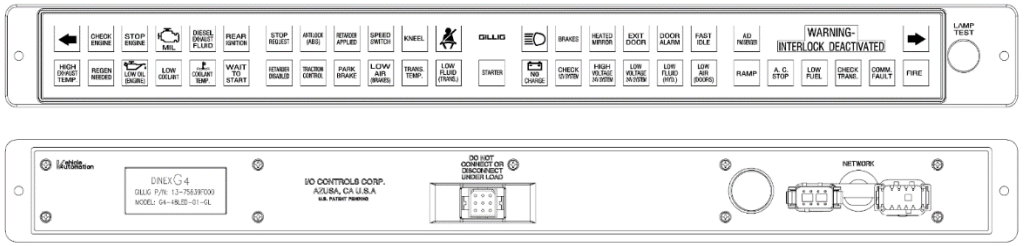


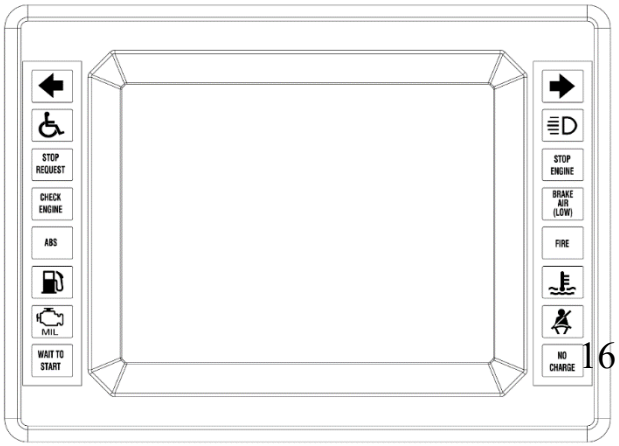


Multiplexing Components

- Digital Output Controller (DIO 40 Out)
- 48 Output Digital Interface Module (Light Bar) A1
- Multi Function Display (MFD DIO)

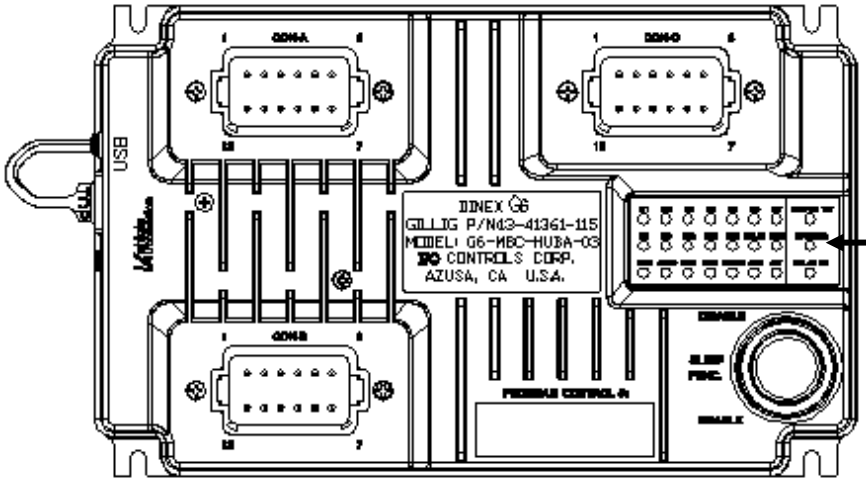






G6 Power Management Supply

- The PMS is integrated into the G6-MBC
- Provides clean 12 VDC power supply to all Dinex system components
- Clean power means free from EMI and RFI
- 24 VDC to 12 VDC converter
- Input voltage below 20 VDC and output voltage below 9 VDC will cause system malfunctions
- 12 VDC is only used to power the module logic
- Has sleep mode for reduced battery drain



G6 PMS LED INDICATORS

- OUTPUT 12 V GREEN LED:

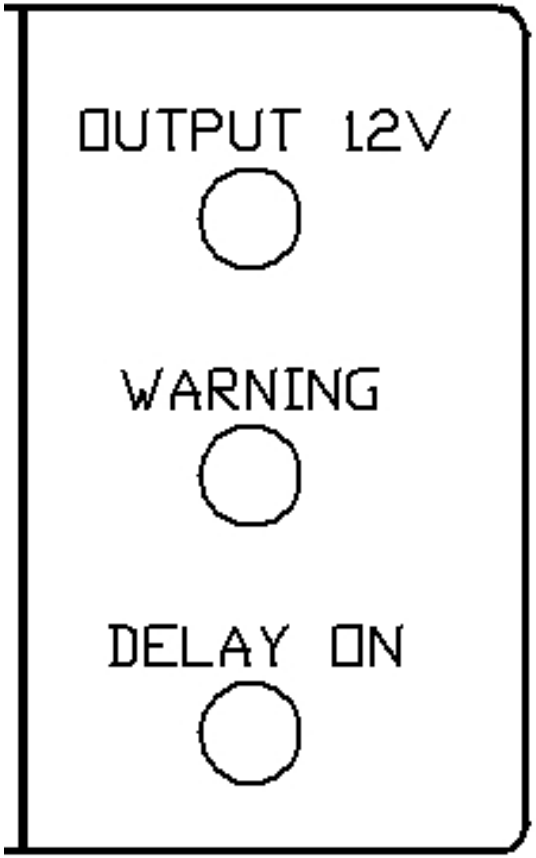
Indicates if the DC to DC converter is operating. If it is “OFF”, the unit has failed, or 24 volt supply is interrupted. The LED should be lit when the system is active.

- WARNING RED LED:

Indicates a low voltage condition below 20 volts supply voltage. Should never be ON. If on, check the vehicle charging system.

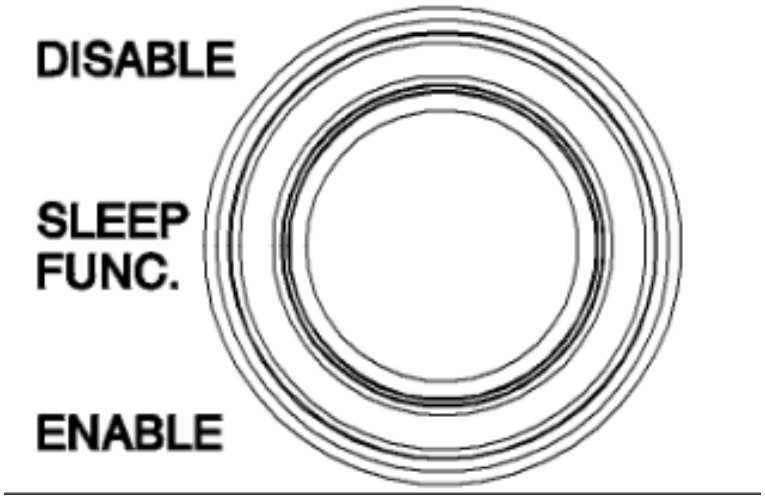
- DELAY “ON” GREEN LED:

Indicates if the PMS programmed delay (1 minutes) is activated. Should start the countdown when the master switch (and hazards,w/c) is turned OFF and program delay has expired.



G6 PMS SLEEP SWITCH

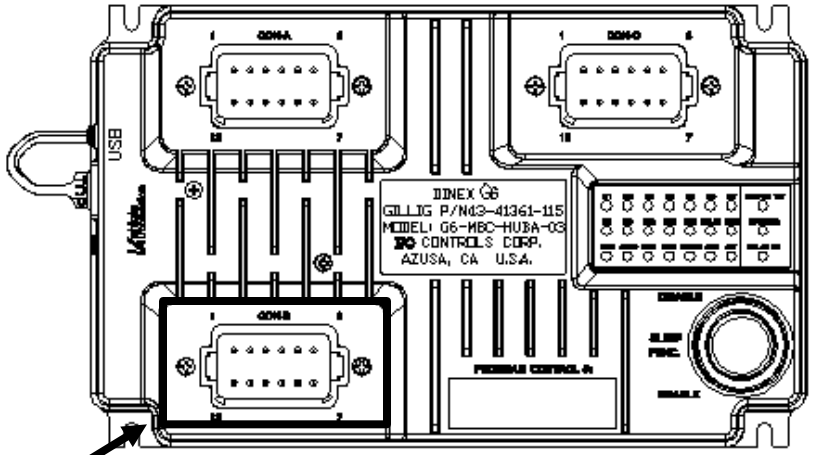
- The Sleep Function switch is located on the right side front of the MBC/PMS
- When in the ENABLE position it allows the Dinex system to go to sleep, preventing battery discharge
- If the switch is in the DISABLE position, the Dinex system will remain active.
- Gillig recommends leaving the switch in the ENABLE position for units in regular service



CONNECTOR B (BROWN CONNECTOR)

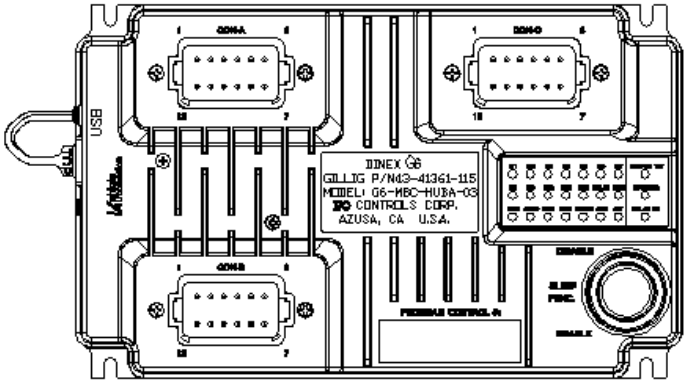
BROWN CONNECTOR **PMS** PIN CONFIGUATION

DT15-12PD CON-B BROWN	
PIN	FUNCTION
1	DINEX CAN-HI_A
2	DINEX CAN-LO_A
3	DINEX +12V, Isolated
4	DINEX Ground, Isolated
5	DINEX CAN-Shield_A
6	SLEEP DISABLE Status Output +
7	Uplink CAN-Shield (Diagnostic Utility Port)
8	Wake-Up PMS (POWER ACTIVE)
9	Uplink CAN-L (Diagnostic Utility Port)
10	Uplink CAN-H (Diagnostic Utility Port)
11	Battery Ground (PMS)
12	Battery +24V (PMS)



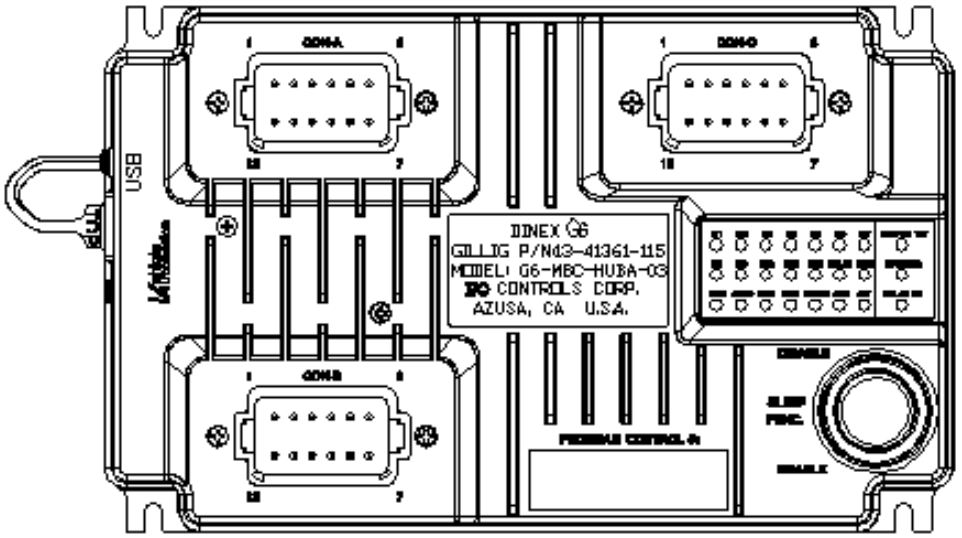
General Differences G6 vs G5 vs G4

- Faster processor than G4 allowing for faster scan time of programs
- G6 has more timers available than G4 and G5 (ID #80)
- G6 has Primary, Secondary and Tertiary CAN networks all 500k with 3 more additional possible (G5 has Primary and Secondary at 500k)
- G6 uses G5 DIO 1616 modules
- G5 DIO modules have FB circuits for outputs 1-13 that can be turned off/on
- G5 DIO - i16 is Resistance analog input instead of Voltage analog input
- Voltage analog inputs are scalable between 0-5V or 0-32V (program dependent)
- G6 has more digital messaging overall between networks 1,2,3



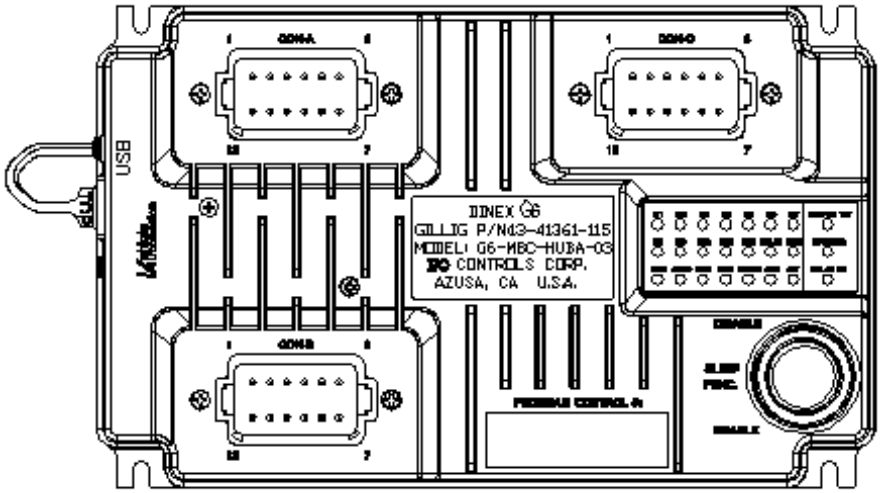
G6 Main Bus Controller/MBC

- TECHNICAL SPECIFICATIONS
  - 250 K Dinex Multiplex Data Communications Rate CAN 2.0 protocol
  - 500K Primary J1939 Data Bus Communication
  - 500K Secondary J1939 Data Bus Communication
  - 500K Tertiary J1939 Data Bus Communication
  - Operating Temperature Range. -40 degrees to +85 degrees Celsius
  - Humidity 10% to 100%
  - Shock up to 20g



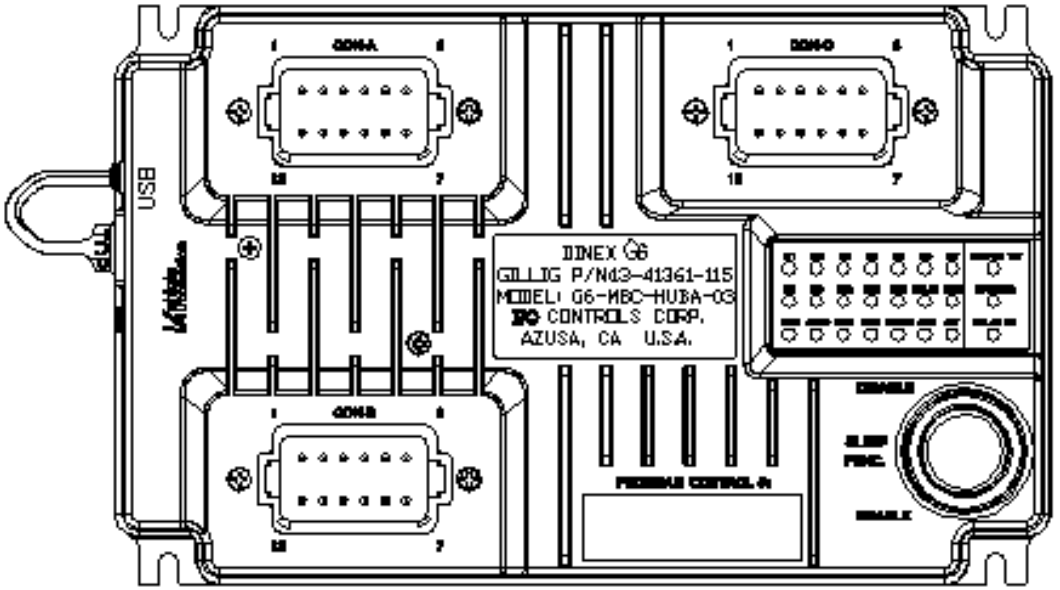
G6 Main Bus Controller/MBC

- Network controller with on-board diagnostics
- Controls other modules and itself
- Must be programmed to function correctly
- Used for tasks requiring multiple conditions
- Has different identifier LED's for diagnosis and troubleshooting
- Has onboard gateway modules for interfacing with the bus J1939 network
- Interfaces with laptop for programming and diagnostics



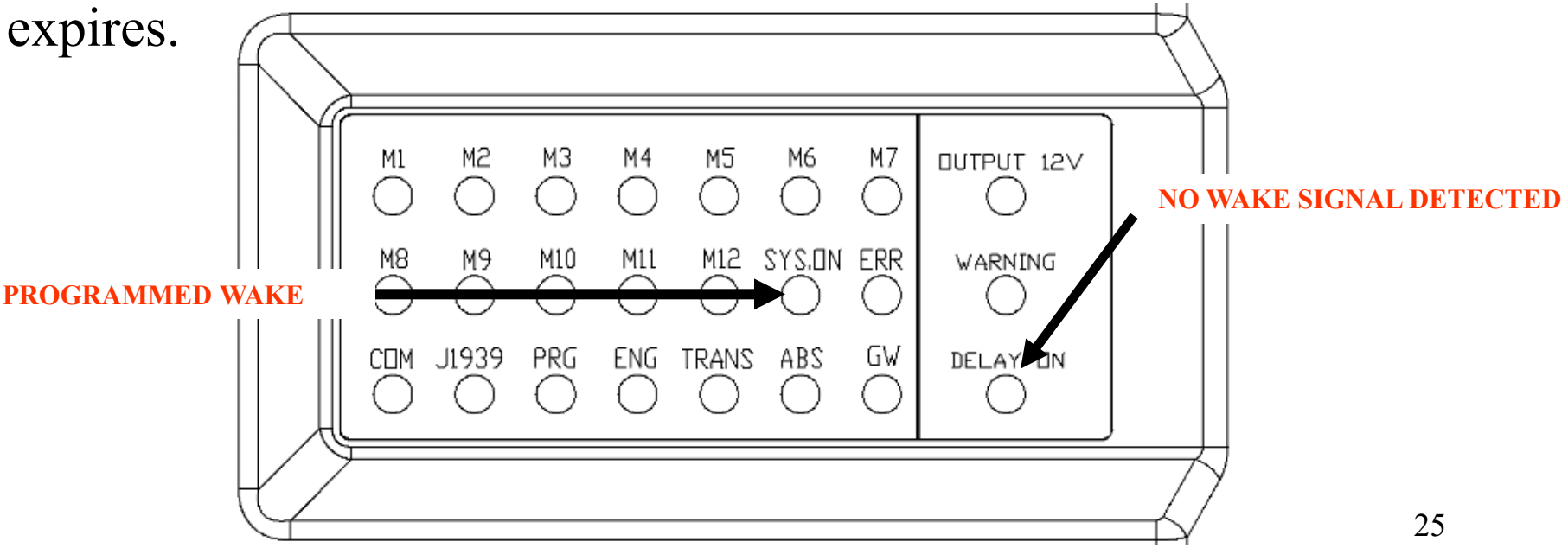
G6 Main Bus Controller/MBC

- Module has an USB connector for utilizing diagnostic software and changing system software/firmware without disconnecting from the network
- MBC has six distinct addresses
  - Id77-System Program (MBC)
  - Id80-Timer Board (128)
  - Id89-G1 Gateway
  - Id90-G2 Gateway
  - Id91-G3 Gateway
  - Id92-G4 Gateway
  - 128/128 per GW



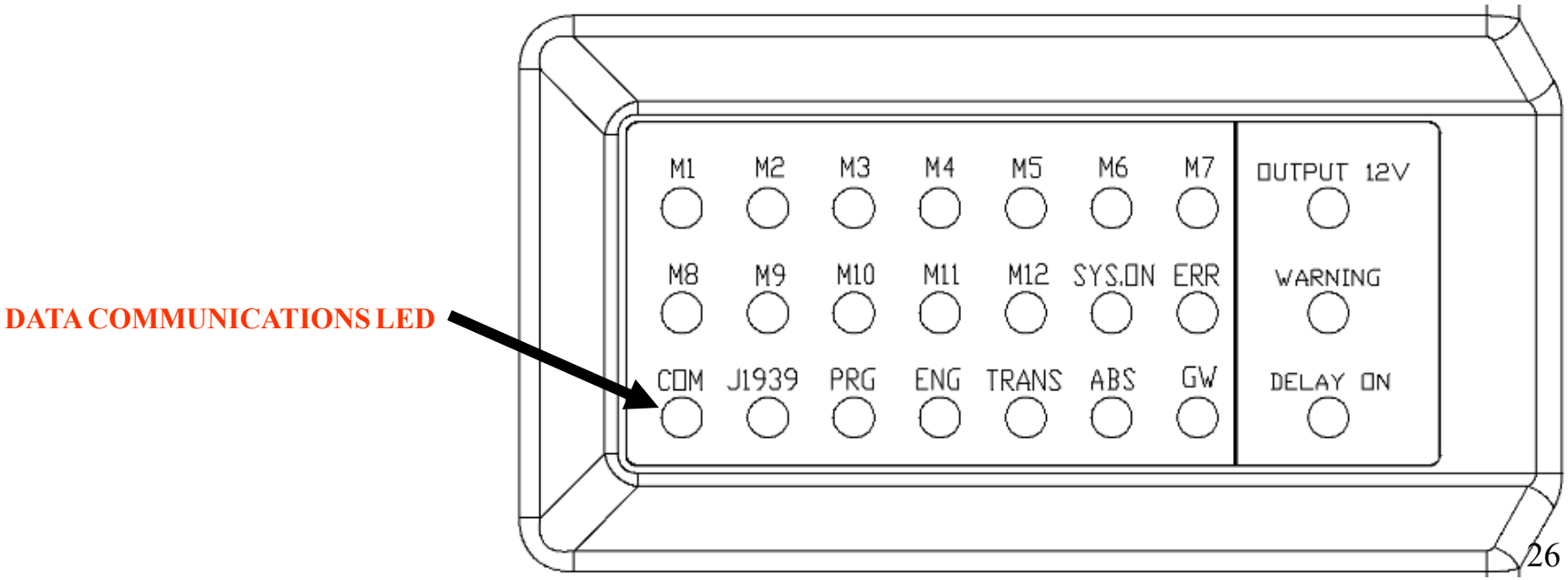
MBC LED INDICATORS

- The “RED” System On indicator is used when the MBC program generates a keep awake signal to prevent PMS from entering Sleep Mode (Countdown to sleep). Usually 4 minutes.
- Delay On LED is on when sleep function is enabled and no wake signal is being received. Will sleep when program timer (1 minute) expires.



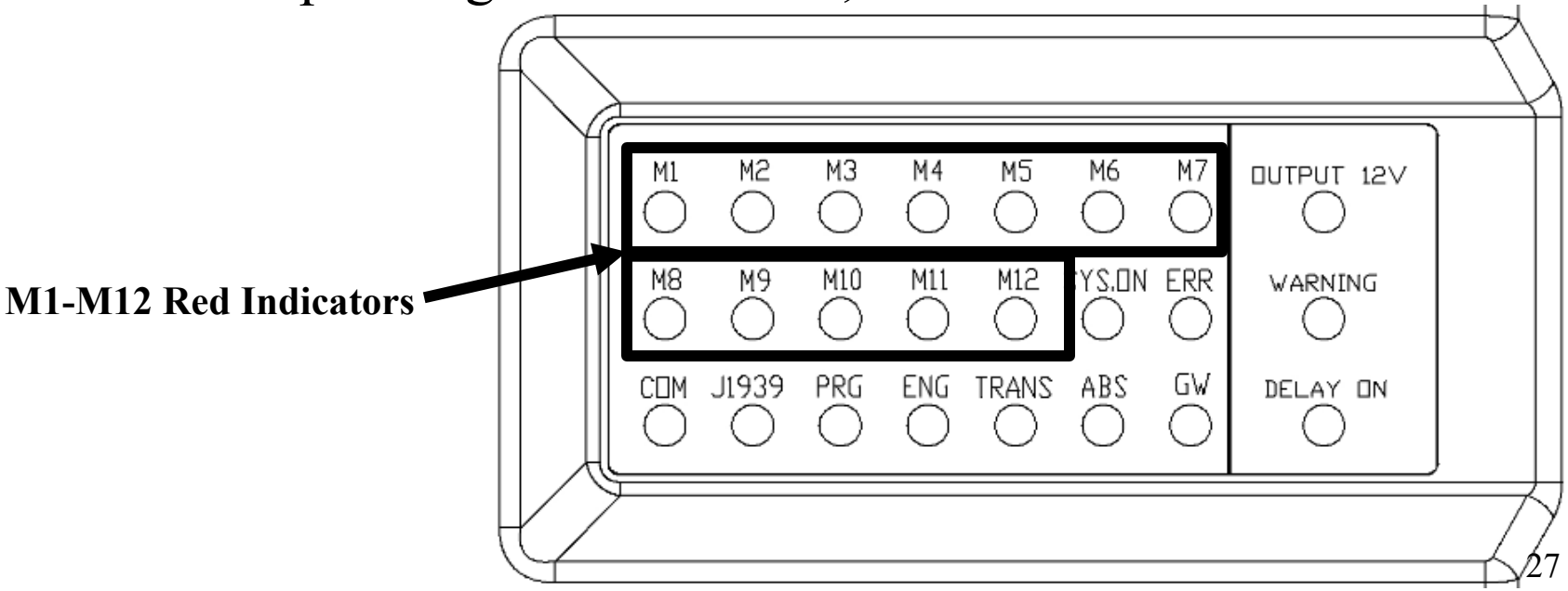
MBC LED INDICATORS-COM

- The “RED” Data Communications LED should be flashing steady whenever the I/O Modules are actively communicating with the MBC
- If not flashing, that MBC may be out of the Data loop. Check the Multiplex (Processor Power) communication loop pages for additional information



MBC LED INDICATORS M1-M12

- Led's M1 through M12 are used to indicate the I/O modules are communicating with the MBC
- The MBC monitors system ID's and will light the "M" led if the module is communicating
- If the corresponding "M" led is off, that module is not communicating

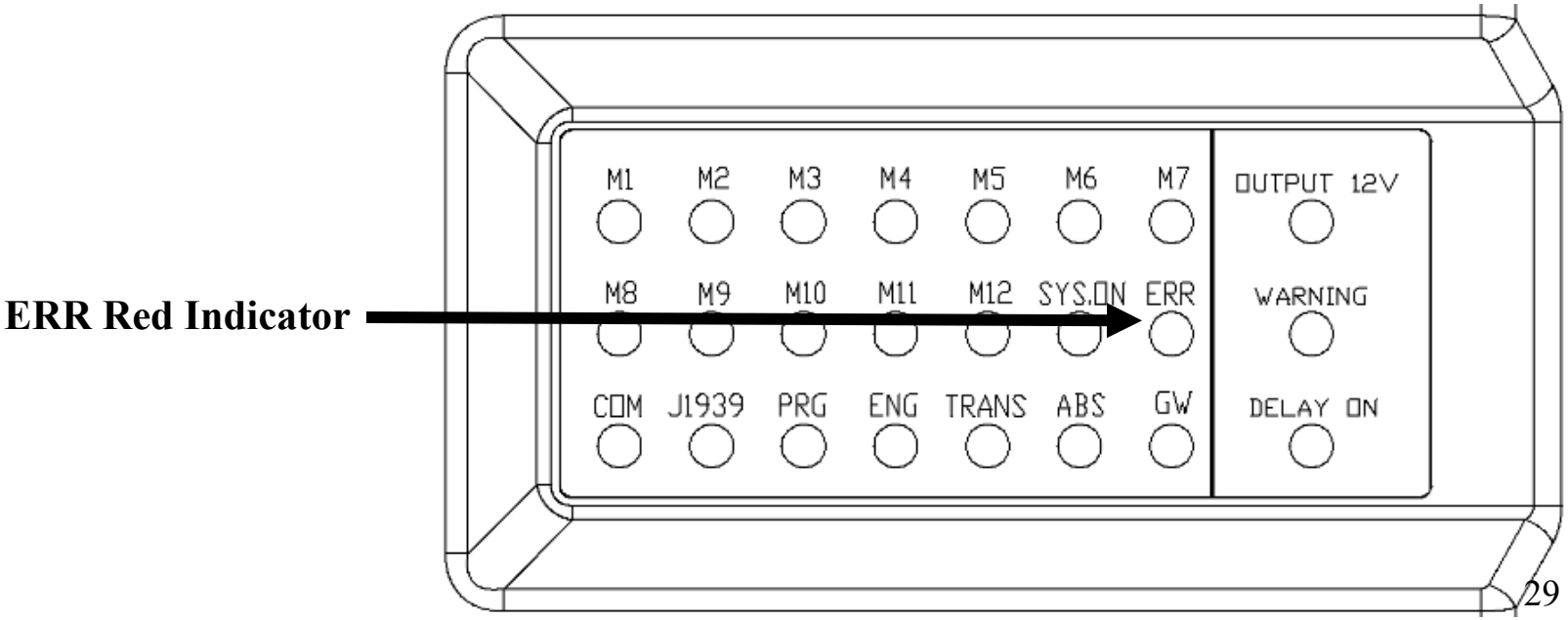


MBC LED M1-M12

- Dinex Multiplex Communication Status, designated **M1 to M12**
  - **M1** = ID# 64, Module B1
  - **M2** = ID# 65, Module B2
  - **M3** = ID# 66, Module B3
  - **M4** = ID# 67, Module B4
  - **M5** = ID# 68, Module B5
  - **M6** = ID# 69, Module C1
  - **M7** = ID# 70, Module D1
  - **M8** = ID# 71, Module D2
  - **M9** = ID# 72, Module D3
  - **M10** = ID# 88, Module R1
  - **M11** = ID# 93, Module A1 or ID# 86, Module A2
  - **M12** = ID# 84, Module LE

MBC LED INDICATORS ERR

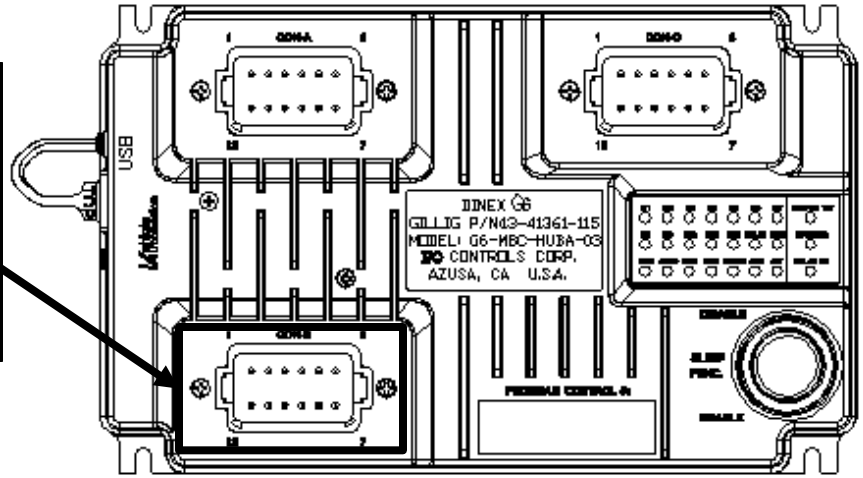
- The ERR Led is used to indicate if the DINEX CAN “A” network has lost communication on the DINEX network for the specified amount of time in the IDE program and the DINEX CAN “B” is activated in the MBC.
- Will be ON when CAN “B is active



DINEX NETWORK

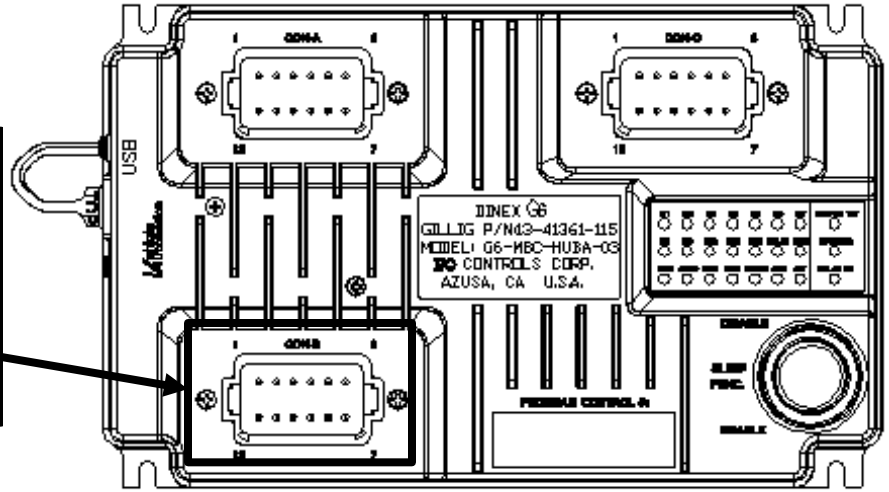
BROWN CONNECTOR B, **DATA CAN A** PIN CONFIGUATION

DT15-12PD CON-B BROWN	
PIN	FUNCTION
1	DINEX CAN-HI_A
2	DINEX CAN-LO_A
3	DINEX +12V, Isolated
4	DINEX Ground, Isolated
5	DINEX CAN-Shield_A
6	SLEEP DISABLE Status Output +
7	Uplink CAN-Shield (Diagnostic Utility Port)
8	Wake-Up PMS (POWER ACTIVE)
9	Uplink CAN-L (Diagnostic Utility Port)
10	Uplink CAN-H (Diagnostic Utility Port)
11	Battery Ground (PMS)
12	Battery +24V (PMS)



DINEX NETWORK

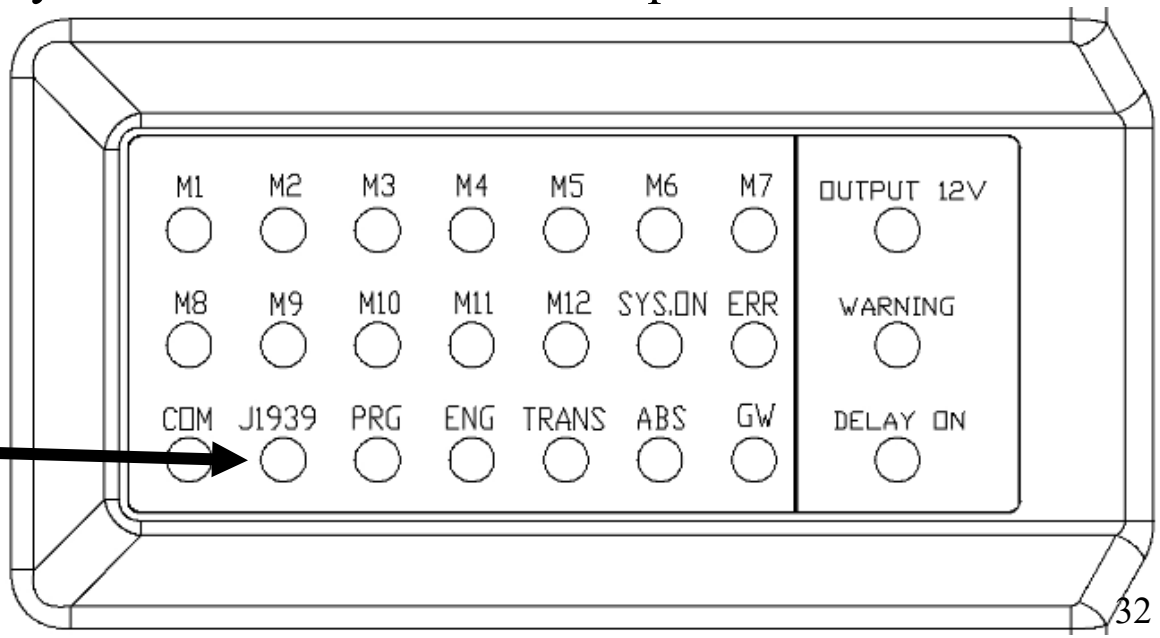
DT15-12PC CON-A GREEN	
PIN	FUNCTION
1	DINEX CAN-HI_B
2	DINEX CAN-LO_B
3	+12V, Isolated
4	Ground, Isolated
5	DINEX CAN-Shield_B
6	N/C
7	Primary(CAN1) J1939 CAN-HI
8	Primary(CAN1) J1939 CAN-LO
9	Primary(CAN1) J1939 CAN-Shield
10	Secondary(CAN1) CAN-HI
11	Secondary(CAN2) CAN-LO
12	Secondary(CAN2) CAN-Shield



MBC LED INDICATORS-J1939

- When on, the J1939 Led is used to indicate if the Primary J1939 CAN BUS is communicating with I/O Controls
- The primary CAN BUS communication bus is sharing data between I/O controls and the drive train (Gillig) network.
- This communication is at 500k
- The secondary and tertiary CAN BUS networks also operate at 500k.

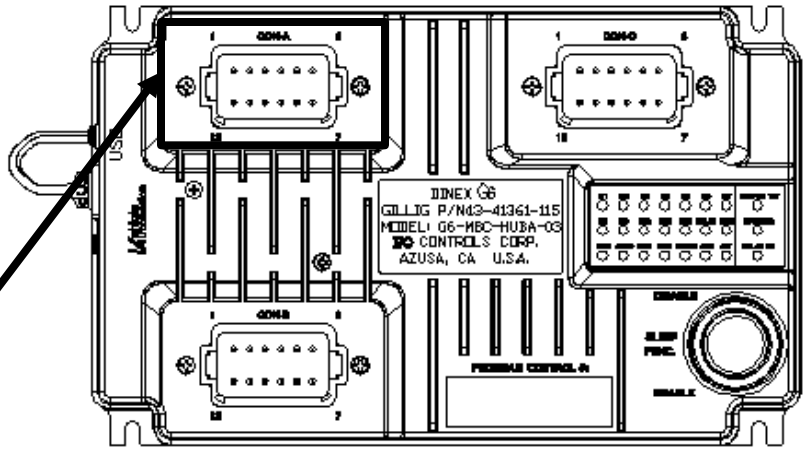
J1939 Red Indicator



CONNECTOR A (GREEN CONNECTOR)

GREEN CONNECTOR **PRIMARY/SECONDARY J1939** PIN CONFIGUATION

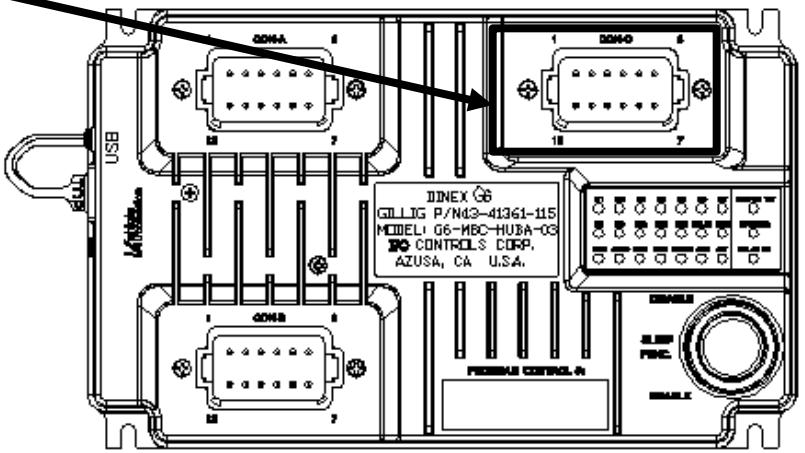
DT15-12PC CON-A GREEN	
PIN	FUNCTION
1	DINEX CAN-HI_B
2	DINEX CAN-LO_B
3	+12V, Isolated
4	Ground, Isolated
5	DINEX CAN-Shield_B
6	N/C
7	Primary(CAN1) J1939 CAN-HI
8	Primary(CAN1) J1939 CAN-LO
9	Primary(CAN1) J1939 CAN-Shield
10	Secondary(CAN1) CAN-HI
11	Secondary(CAN2) CAN-LO
12	Secondary(CAN2) CAN-Shield



CONNECTOR A (GREEN CONNECTOR)

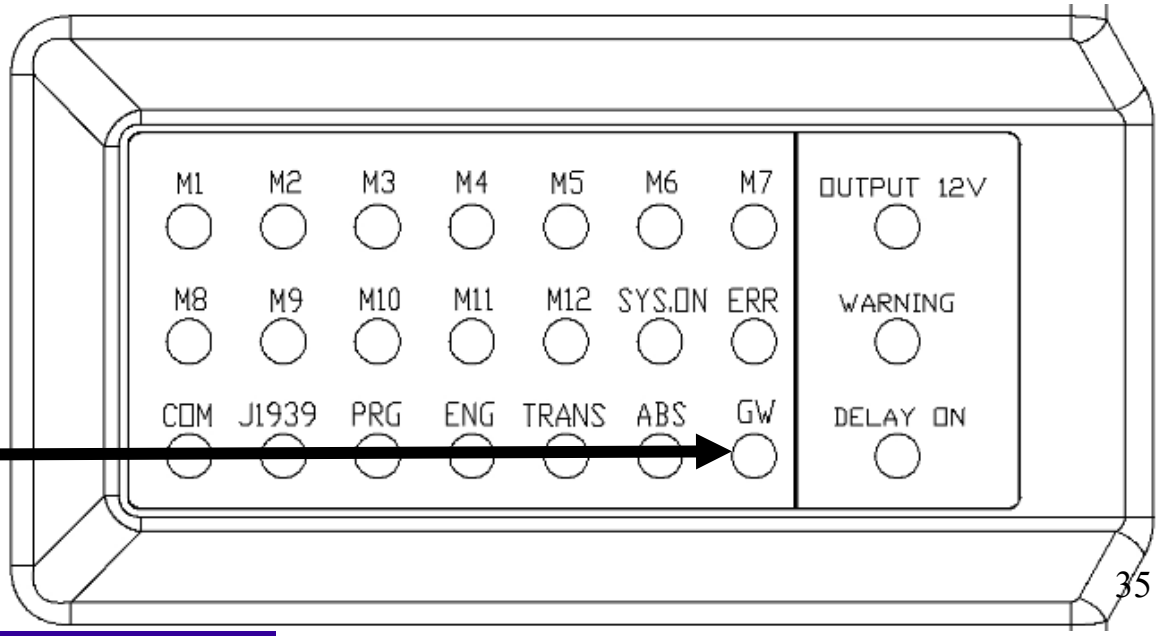
BLACK CONNECTOR **THIRD J1939** PIN CONFIGUATION

DT15-12PB CON-C BLACK	
PIN	FUNCTION
1	Third (CAN3) J1939 CAN-HI
2	Third (CAN3) J1939 CAN-LO
3	Third (CAN3) J1939 CAN-Shield
4	RESERVED
5	RESERVED
6	RESERVED
7	RESERVED
8	RESERVED
9	RESERVED
10	RESERVED
11	RESERVED
12	RESERVED



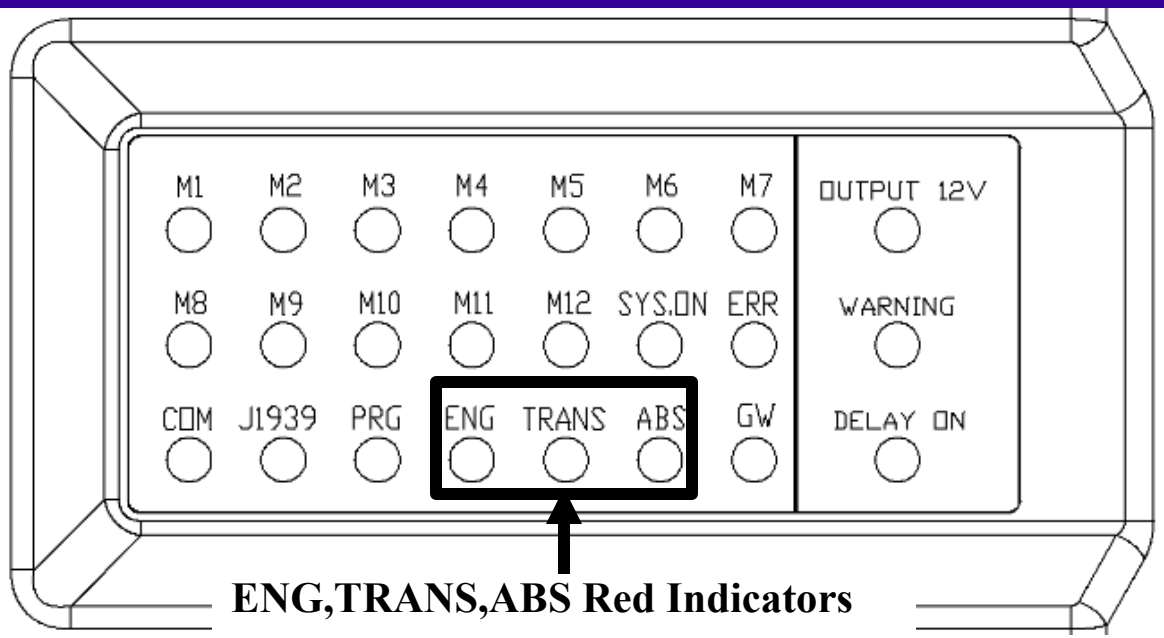
MBC LED INDICATORS-J1939

- If on, the GW (Gateway) chip is powered and sending and receiving data between the bus (Gillig) and IO controls networks
- There are 4 gateways inside the MBC on a single board, 128 inputs/128 outputs each.
- If any of the gateways fail to communicate, LED will be off and the COMM Fault light on the light bar (MFD) will flash, identifying which of the 4 is not communicating



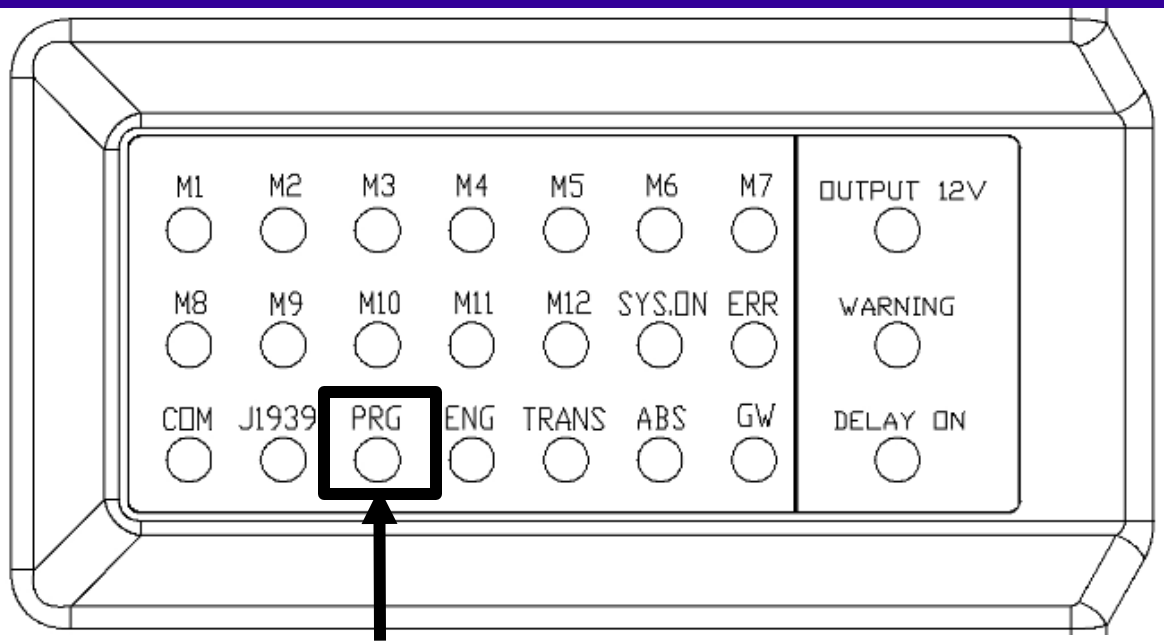
GW Red Indicator

MBC LED INDICATORS-J1939



- If on, these indicators are used to let the technicians know if the Engine, Transmissions and ABS controllers are communicating through the Primary gateway connection within the last 10 seconds
- I/O controls refers to this as heartbeat
- Refer to the J1939 Communication pages in the Gillig electrical schematic manual for details

MBC LED INDICATORS-J1939

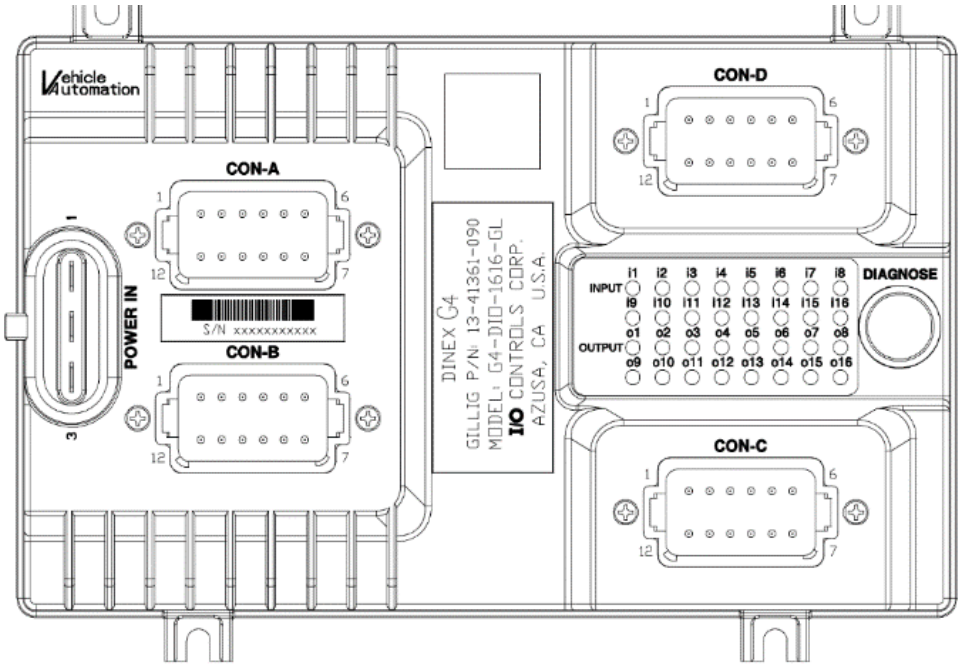


PRG Red Indicators

- The PRG led will be on when a program is being downloaded to the MBC module or the Real Time Monitor software is running

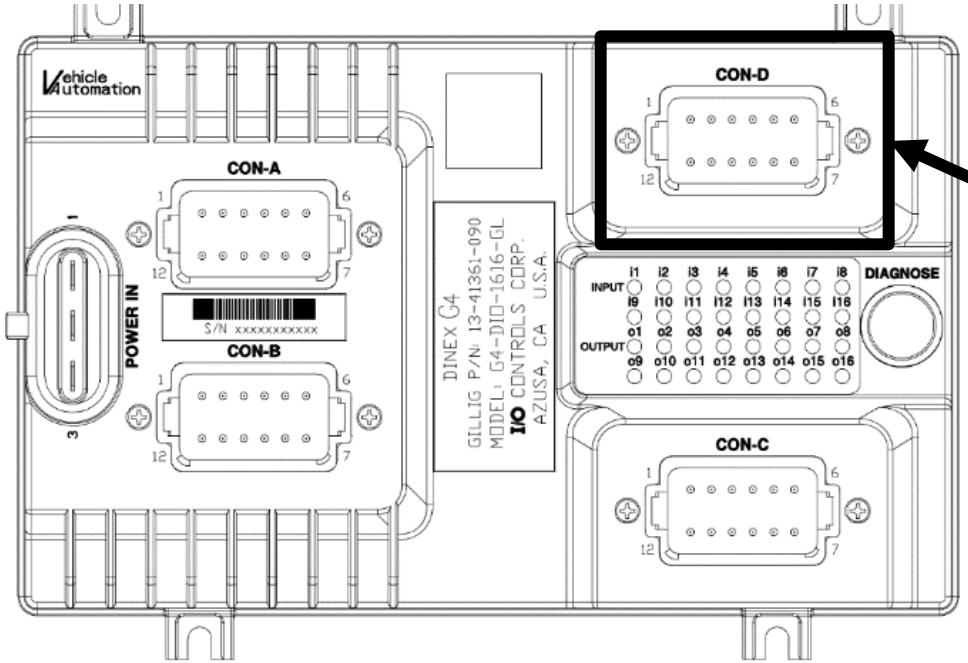
G5 Digital Input and Output Controller (DIO 1616)

- Worker module, no changeable programming
- Interchangeable with other DIO 1616's, if it has the same part number.
- Address is hardwired in the harness
- 16 inputs and 16 outputs
- Used for on/off work only



1616 DINEX NETWORK

- The power and ground from the PMS to the I/O modules is found at connector D, Brown
- Pin 3 is 12 volt isolated power, Pin 4 is isolated ground
- Pins 1,2 and 5 are Dinex Network wires, allowing communication with MBC



CON-D BROWN DT15-12PD	
PIN	FUNCTION
1	DINEX CAN_H
2	DINEX CAN_L
3	+12V, ISOLATED
4	GND, ISOLATED
5	DINEX CAN_SHIELD
6	INPUT 15 (Analog 1)
7	INPUT 16 (Analog 2)
8	ID SELECT GND
9	ID SELECT ADDR1
10	ID SELECT ADDR2
11	ID SELECT ADDR3
12	ID SELECT ADDR4

G5 DIO ADDRESSING

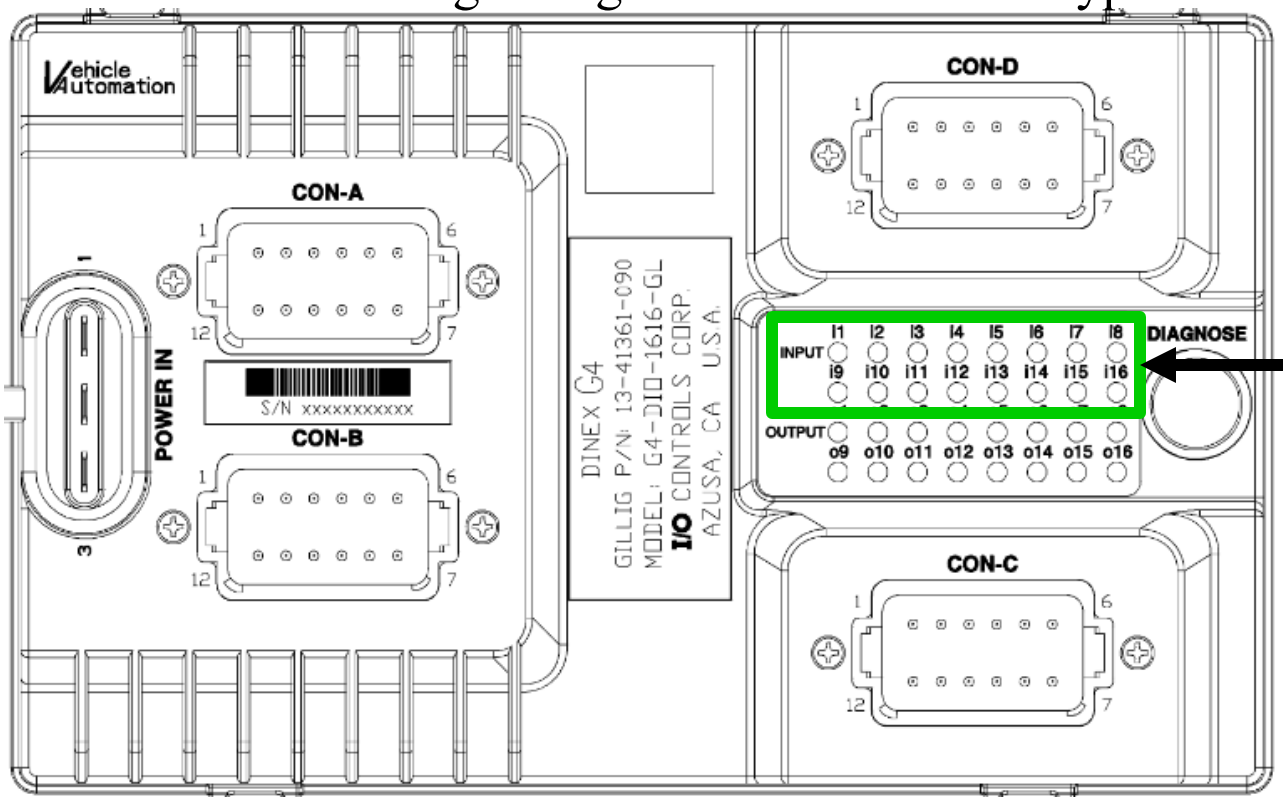
- The addresses of the modules are used to identify them in the Dinex network. Modules broadcast and receive messages to/from the MBC.
- Addresses on G4 modules are hardwired in the harness connected to the module
- The ID pins are in the “D Brown Connector”

CON-D BROWN DT15-12PD	
PIN	FUNCTION
1	DINEX CAN_H
2	DINEX CAN_L
3	+12V, ISOLATED
4	GND, ISOLATED
5	DINEX CAN_SHIELD
6	INPUT 15 (Analog 1)
7	INPUT 16 (Analog 2)
8	ID SELECT GND
9	ID SELECT ADDR1
10	ID SELECT ADDR2
11	ID SELECT ADDR3
12	ID SELECT ADDR4

Module ID Selection/Jump Table (REF: CON D)	
ID	Jump Pins
64	8-9-10-11-12
65	8-10-11-12
66	8-9-11-12
67	8-11-12
68	8-9-10-12
69	8-10-12
70	8-9-12
71	8-12
72	8-9-10-11
73	8-10-11
74	8-9-11
75	8-11
76	8-9-10
77	8-10
78	8-9

G5 DIO LED INDICATORS

- GREEN LED's I1 through I16 indicates an input has been made through a switch, sensor or ECU attached to that particular LED. Input current will be Ground, 12VDC, or 24VDC.
- When these GREEN LED's light, a digital signal is generated, encoded, and transmitted to the MBC. This digital signal is used for some type of control in the system



G5 DIO INPUT INDICATORS

- Inputs consist of 16 wires (Input 1 through 16)
- These wires are the inputs (12V, 24V or GND) from switches, sensors or ECU's to the modules
- The "Input Common" terminals (Pin 8 &9) complete the circuit (power or ground)
- These inputs are what initiate the digital signals generated by the modules
- "GREEN" LED's I1 through I16 indicates an input has been made through a switch, sensor or ECU attached to that particular input
- When these "GREEN" LED's light, a digital signal is generated, encoded and transmitted to the MBC. This digital signal is used for some type of control in the system

CON-C GREEN DT15-12PC	
PIN	**FUNCTION**
1	OUTPUT 14H (0.12A)
2	OUTPUT 14L (0.12A)
3	OUTPUT 15 (Sink 1.0A)
4	OUTPUT 16 (Sink 1.0A)
5	OUTPUT 15-16 COM Ground
6	INPUT 13
7	INPUT 14
8	COM 1-6
9	COM 7-14
10	COM Ground
11	COM Power
12	INPUT 12

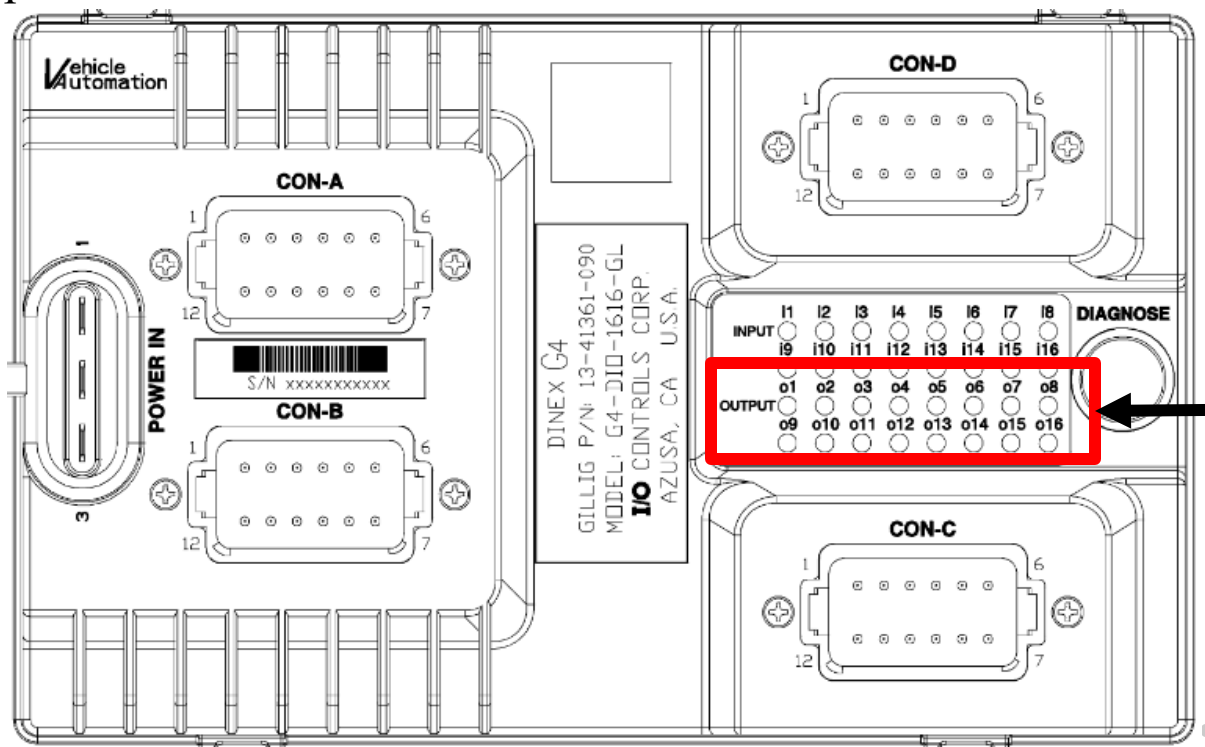
G5 DIO INPUT INDICATORS

- Input 15 can be configured to be a positive voltage input or a voltage analog input that is programmable for either 0-5 or 0-32vdc. Input LED won't work if analog voltage is below approx. 8 vdc.
- Input 16 can be configured to be a positive voltage input or a resistance analog input. Input LED will not work in resistance input
- Analog input data can be read by the MBC to be used in the program to activate an output

CON-D BROWN DT15-12PD	
PIN	**FUNCTION**
1	DINEX CAN_H
2	DINEX CAN_L
3	+12V, ISOLATED
4	GND, ISOLATED
5	DINEX CAN_SHIELD
6	INPUT 15 (Analog 1) VOLTAGE
7	INPUT 16 (Analog 2) RESISTOR
8	ID SELECT GND
9	ID SELECT ADDR1
10	ID SELECT ADDR2
11	ID SELECT ADDR3
12	ID SELECT ADDR4

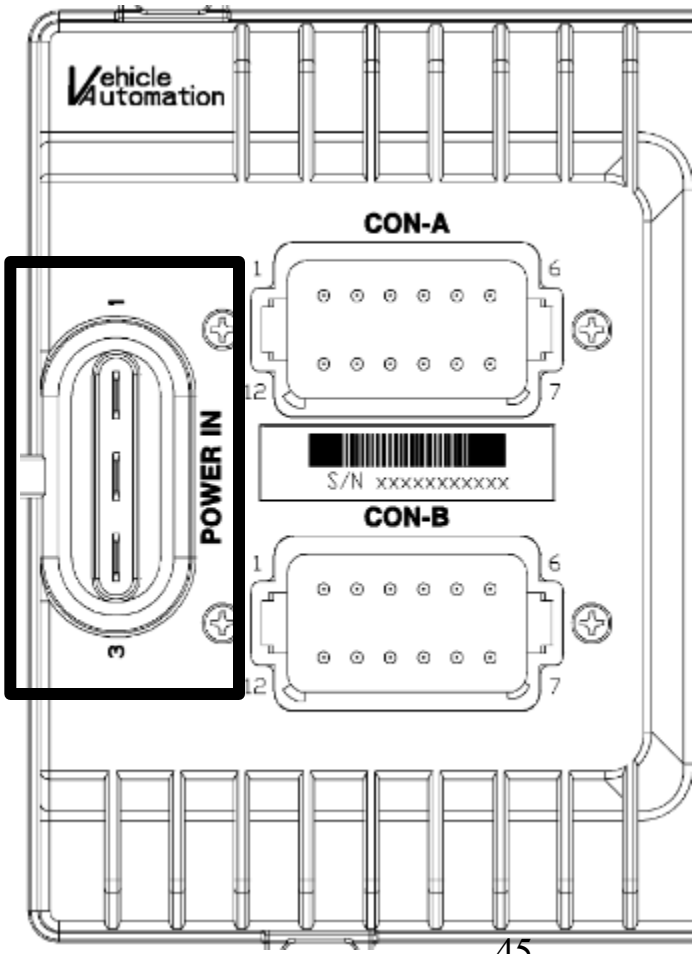
G5 DIO LED OUPUT INDICATORS

- "RED" LED's o1 through o16 on the modules indicate that the module has received a command from the MBC and is attempting to send current to the load
- Current sent to the loads can be either 12V, 24V, or Ground depending on how the module is wired
- The output MOSFETs are protected by Smart circuits inside the module that limit current, voltage and temperature



DIO 1616 POWER IN CONNECTOR

- The Power In Connector consists of 3 wires
- Pin 1 and Pin 3 provide supply current, in the form of voltage, for all voltage outputs in the module.
- The voltage supply to these can be 12 or 24 volts
- Pin 1 is for outputs 1,2,5,6,7,8,9
- Pin 3 is for outputs 3,4,10,11,12,13
- Pin 2 provides chassis ground for the module



DIO 1616 OUTPUT CURRENT RATINGS

Output	Output Type	Continuous Current Rating	
1	Power Group A	10 Amp	PWM 01
2	Power Group A	10 Amp	PWM 02
3	Power Group B	10 Amp	PWM 03
4	Power Group B	10 Amp	PWM 04
5	Power Group A	5 Amp	
6	Power Group A	5 Amp	
7	Power Group A	5 Amp	
8	Power Group A	5 Amp	
9	Power Group A	5 Amp	
10	Power Group B	5 Amp	
11	Power Group B	5 Amp	
12	Power Group B	5 Amp	
13	Power Group B	5 Amp	
14	Power or Ground	0.120 Amp	
15	Ground	1 Amp	
16	Ground	1 Amp	

DIO 1616 OUTPUT 15 & 16

- Outputs 15 and 16 are dedicated as ground outputs.
- These outputs are limited to 1.0 amperes
- Pin 5 provides the ground supply current for both outputs

CON-C GREEN DT15-12PC	
PIN	**FUNCTION**
1	OUTPUT 14H (0.12A)
2	OUTPUT 14L (0.12A)
3	OUTPUT 15 (Sink 1.0A)
4	OUTPUT 16 (Sink 1.0A)
5	OUTPUT 15-16 COM Ground
6	INPUT 13
7	INPUT 14
8	COM 1-6
9	COM 7-14
10	COM Ground
11	COM Power
12	INPUT 12

DIO 1616 OUTPUTS

- Outputs Are Smart Fuse Protected Inside The Module
- If the module detects overload or short circuit the smart fuse automatically cuts off power to the output.
- The output indicator light may turn OFF and no power will be supplied to the load.
- Will automatically reset when the output state is cycled.
- Outputs 1, 2, 3, and 4 can be configured to be PWM outputs.
- 100 Hz, 10% through 100% duty cycle
- All other outputs are “ON” or “OFF”

DIO 1616 OUTPUT 14

- Output 14 can be configured to provide either voltage or ground output.
- The power supply wire (12 or 24 volts) when attached to H pin will give voltage to the corresponding L pin when the output is activated (Output 14H to Output 14L)
- The ground supply wire when attached to the L pin will give ground to the H pin when the output is activated (Output l4 L to Output 14 H)

CON-C GREEN DT15-12PC	
PIN	FUNCTION
1	OUTPUT 14H (0.12A)
2	OUTPUT 14L (0.12A)
3	OUTPUT 15 (Sink 1.0A)
4	OUTPUT 16 (Sink 1.0A)
5	OUTPUT 15-16 COM Ground
6	INPUT 13
7	INPUT 14
8	COM 1-6
9	COM 7-14
10	COM Ground
11	COM Power
12	INPUT 12

DIO 1616 PIN OUTS

CON-A GREY DT15-12PA	
PIN	**FUNCTION**
1	OUTPUT 5 (5.0A)
2	INPUT 1
3	OUTPUT 6 (5.0A)
4	INPUT 2
5	OUTPUT 1 (10.0A)
6	INPUT 3
7	OUTPUT 2 (10.0A)
8	INPUT 4
9	OUTPUT 7 (5.0A)
10	OUTPUT 8 (5.0A)
11	INPUT 5
12	OUTPUT 9 (5.0A)

CON-B BLACK DT15-12PB	
PIN	**FUNCTION**
1	OUTPUT 10 (5.0A)
2	INPUT 6
3	OUTPUT 11 (5.0A)
4	OUTPUT 12 (5.0A)
5	INPUT 7
6	OUTPUT 3 (10.0A)
7	INPUT 8
8	OUTPUT 4 (10.0A)
9	INPUT 9
10	OUTPUT 13 (5.0A)
11	INPUT 10
12	INPUT 11

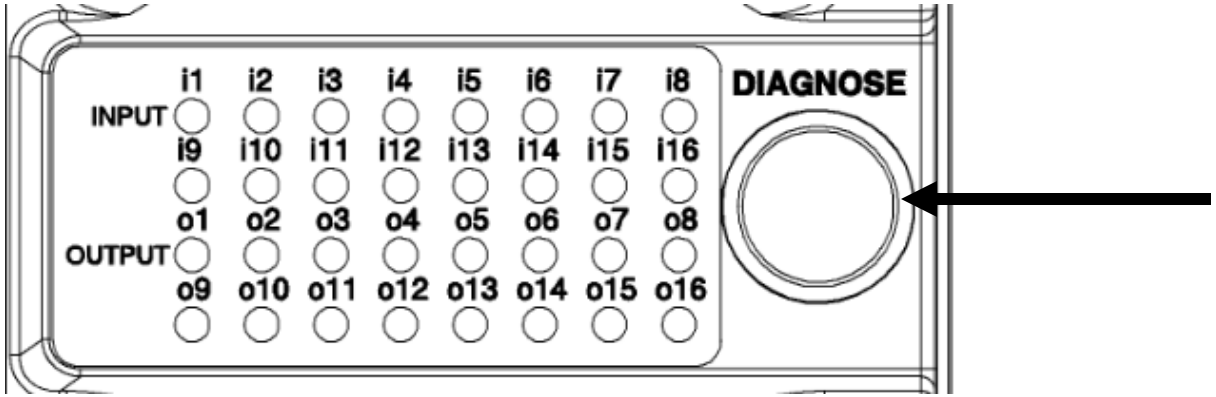
DIO 1616 PIN OUTS

CON-C GREEN DT15-12PC	
PIN	**FUNCTION**
1	OUTPUT 14H (0.12A)
2	OUTPUT 14L (0.12A)
3	OUTPUT 15 (Sink 1.0A)
4	OUTPUT 16 (Sink 1.0A)
5	OUTPUT 15-16 COM Ground
6	INPUT 13
7	INPUT 14
8	COM 1-6
9	COM 7-14
10	COM Ground
11	COM Power
12	INPUT 12

CON-D BROWN DT15-12PD	
PIN	**FUNCTION**
1	DINEX CAN_H
2	DINEX CAN_L
3	+12V, ISOLATED
4	GND, ISOLATED
5	DINEX CAN_SHIELD
6	INPUT 15 (Analog 1)
7	INPUT 16 (Analog 2)
8	ID SELECT GND
9	ID SELECT ADDR1
10	ID SELECT ADDR2
11	ID SELECT ADDR3
12	ID SELECT ADDR4

1616 DIAGNOSE BUTTON

- The diagnose button on the 1616 is used to put the module into a two step troubleshooting mode
- Step one is a module communication test
- Step two is a test for confirming an open Smartfuse



1616 DIAGNOSE BUTTON

Press and hold the button. During the first 10 seconds the module ID and comm status is displayed

- Input indicators continue to display input status
- O09 = ID Select ADDR1
- O10 = ID Select ADDR2
- O11 = ID Select ADDR3
- O12 = ID Select ADDR4
- O16:

  On=Module Communicating

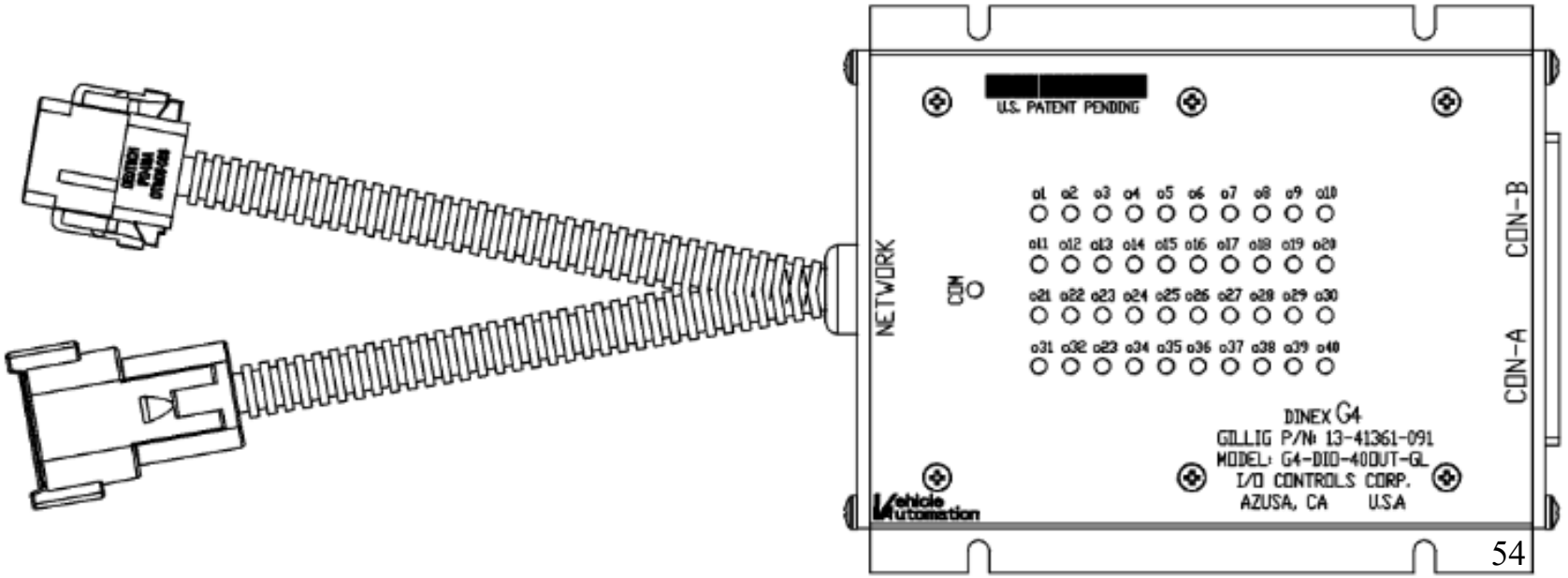
  Off=No Module Comm

MODULE ID

Module ID Selection/Jump Table (REF: CON D)		
ID	**Jump Pins**	**DIAGNOSE**
64	8-9-10-11-12	9 10 11 12
65	8-10-11-12	10 11 12
66	8-9-11-12	9 11 12
67	8-11-12	11 12
68	8-9-10-12	9 10 12
69	8-10-12	10 12
70	8-9-12	9 12
71	8-12	12
72	8-9-10-11	9 10 11
73	8-10-11	10 11
74	8-9-11	9 11
75	8-11	11
76	8-9-10	9 10
77	8-10	10
78	8-9	9

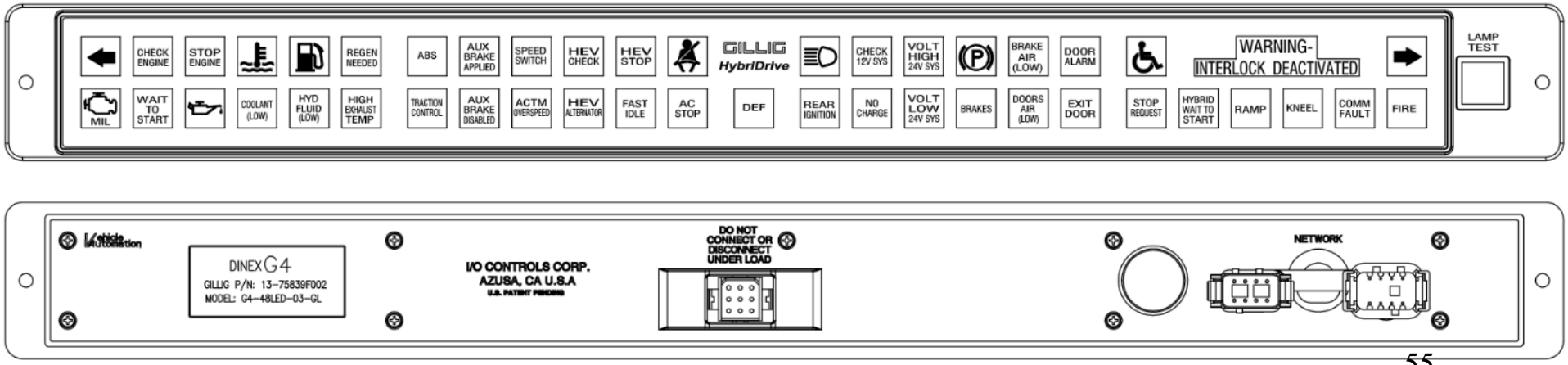
Digital Output Controller (DIO 40 OUT GL)

- Typically module B5
- Used for interfacing with ITS and camera systems.
- Has 40 isolated output points, using Solid-State relays.
- Has LED status indicators provided on all I/O points.
- Each output point has current limit protection to 120mA



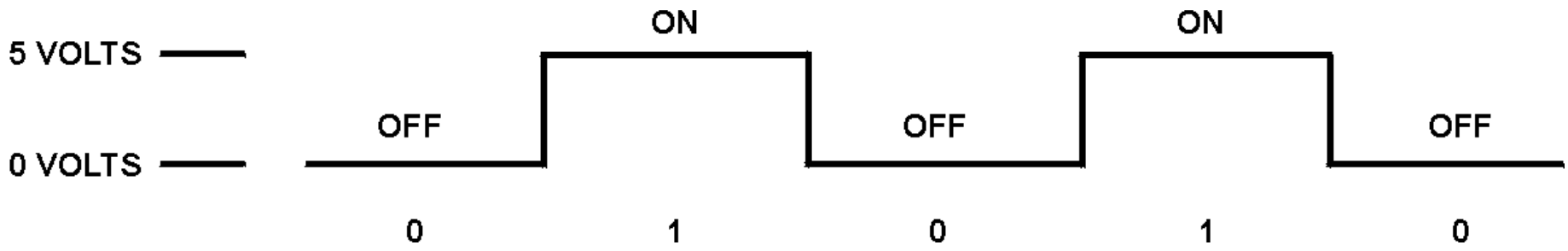
Digital Input Output Controlled (DIO 48 Out)

- When master switch is turned “ON” A1 lights all the LED’s on the indicator panel as a system check
- Most the indicator lamps are digitally controlled by the MBC (MBC initiates when The Test Switch Is Activated, or Master Switch is turned ON)
- Two exceptions are the Cummins MIL and Wait To Start Lamps
- Module A1 has an address of #93 and #94, MFD is 4 boards
- 46 Indicator lamps, 1 buzzer, 1 chime



How Computers Communicate

- The Dinex system is a series of computers tied together to form a network
- These networked computers must communicate with each other to accomplish tasks
- This communication is done with the use of digital signals
- Digital signals are a series of voltage pulses passed back and forth though cabling linking the computers together



What Does All This Mean?

J1939 is simply a protocol or a language used to communicate between CPU's linked together in a network (CAN)

It was establish as the SAE standard in 1994

G4 has a communication or baud rate of approximately 500,000 bps

Gillig uses a J1939-71 for our document protocol

J1939 uses a 29 bit code for communication

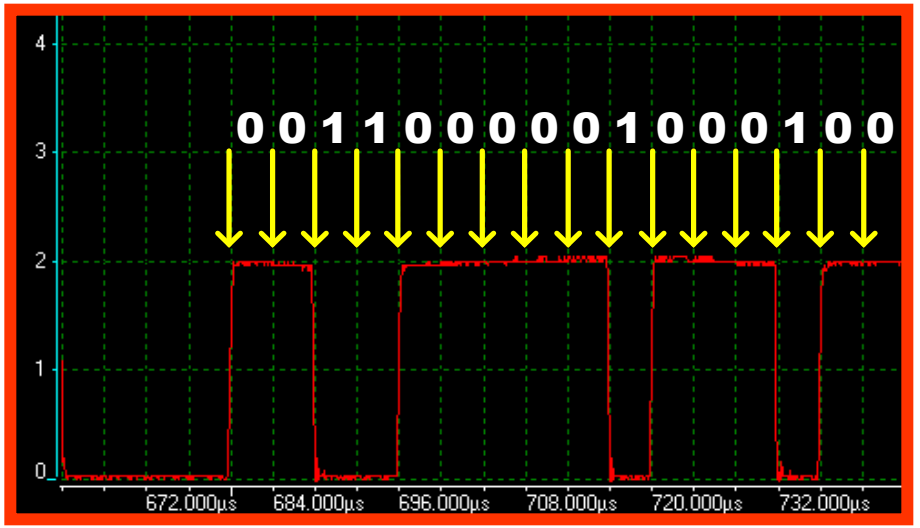
Contained in that 29 bit code is the message priority, address, and the information that needs to be conveyed

Baud Rate and Bits

BAUD RATE – Speed at which information can be transferred. Expressed as the maximum number of state transitions per second (bits per second).

BIT – Short for ‘binary digit’. Smallest piece of information used by a computer.

J1939 runs at 250 or 500 kbps. As an example, 250,000 **bits** of information can be shared each second. The width of a single bit is 1 bit ÷ 250,000 bits per second or 4 µS. Looking at an oscilloscope trace:

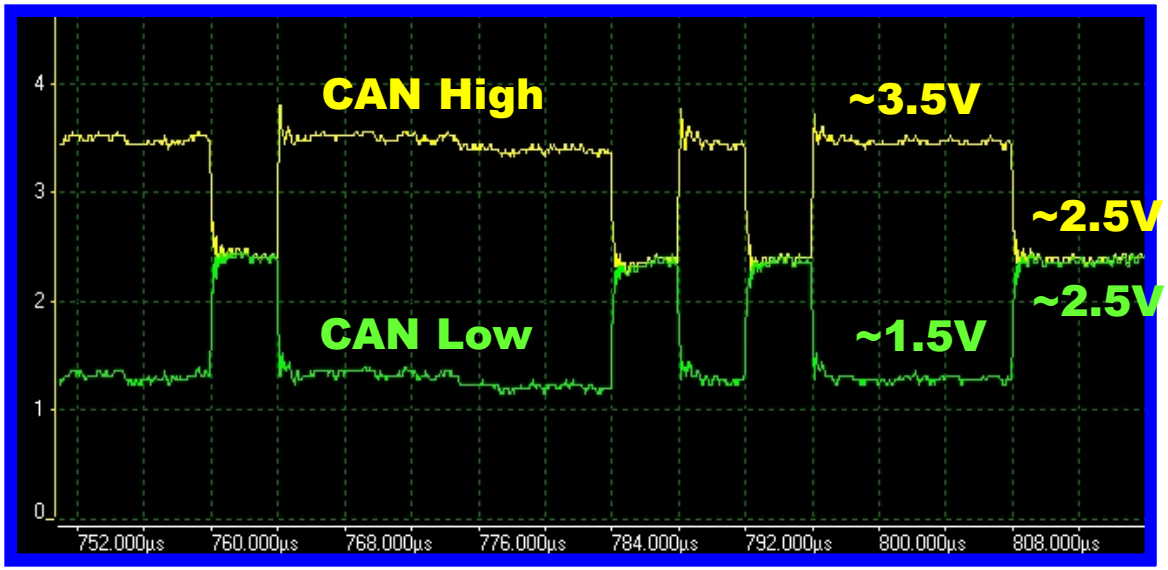


Each tick mark on our scope represents 4 µS, so the trace between tick marks is a bit. Assigning ‘0’ to each dominant bit and ‘1’ to each recessive bit, we end up with a STRING OF BINARY DATA, which is what computers use to communicate.

What Are Digital Signals?

Yellow Trace: Signal lead connected to CAN High, or Pin 'A'. Signal reference connected to ground.

Green Trace: Signal lead connected to CAN Low, or Pin 'B'. Signal reference connected to ground.



Characteristics:

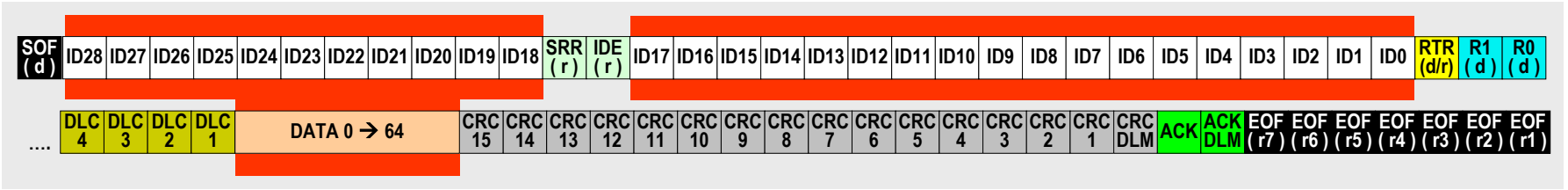
CAN High and CAN Low are 'balanced'; when one is 'up', the other is 'down'.

The voltages changes are low; everything is pretty much ≤ 1.0 volt.

The voltage traces are fairly square, and have only two 'states'.

Either On or OFF representing 1 or 0 (binary code)

J1939 Messages & PGNs



Within a CAN data frame, J1939 concerns itself with the 29-bit ID & data fields:

J1939 PROTOCOL DATA UNIT (PDU) – String of information consisting of the 29-bit identifier & data. There can only be one PDU per CAN data frame.

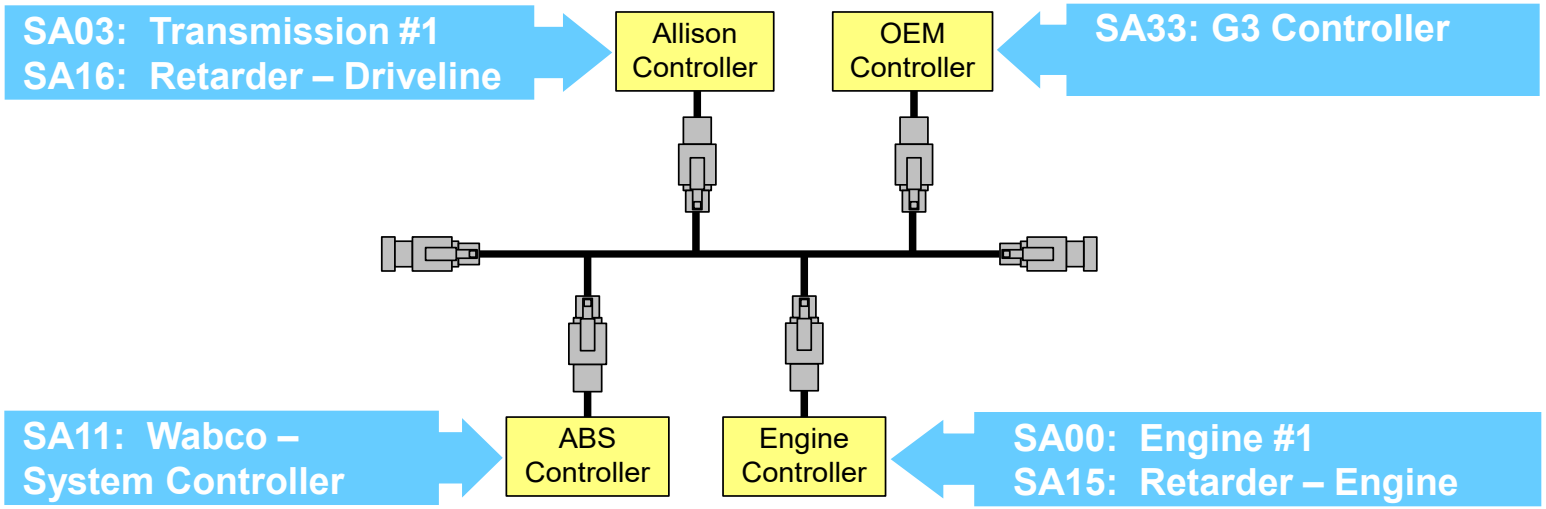
PARAMETER GROUP NUMBER (PGN) – Collection of J1939 parameters that are specified by information within the 29-bit identifier.

- J1939-71 = Application layer PGNs (most)
- J1939-21 = Datalink layer PGNs (requests, transport protocol, etc.)
- J1939-73 = Diagnostic PGNs (DM1, etc.)

J1939 MESSAGE – One *or more* CAN data frames (Protocol Data Units) that have the same Parameter Group Number.

…the terms ‘message’ and ‘PGN’ are used interchangeably.

J1939 Addressing



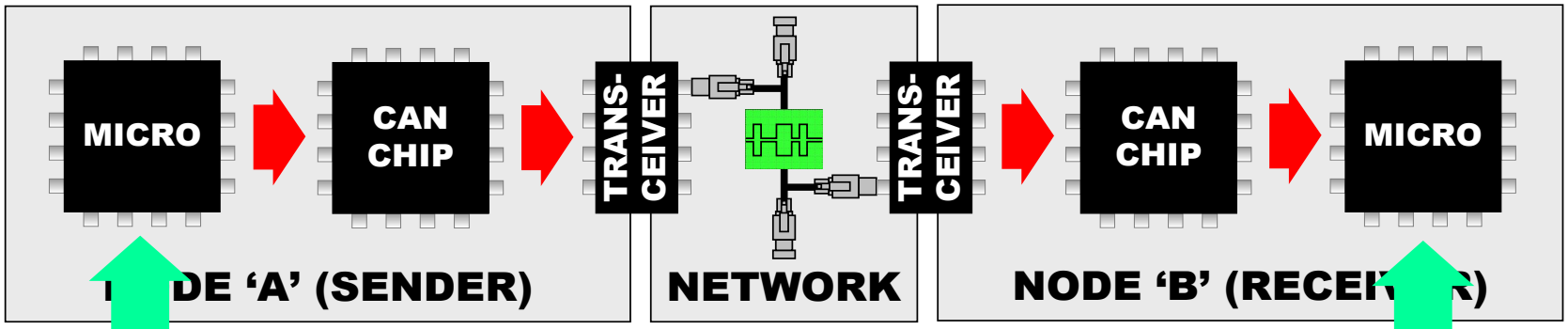
Source Addresses not based on physical controllers, but on functional entities.

One node (physical controller) may use several SA's based on its functions.

Source Addresses may also used be used as Destination Addresses:

DESTINATION ADDRESS (DA) – Specific address to which a J1939 message is sent; any other devices should ignore this message. The global destination address is 255.

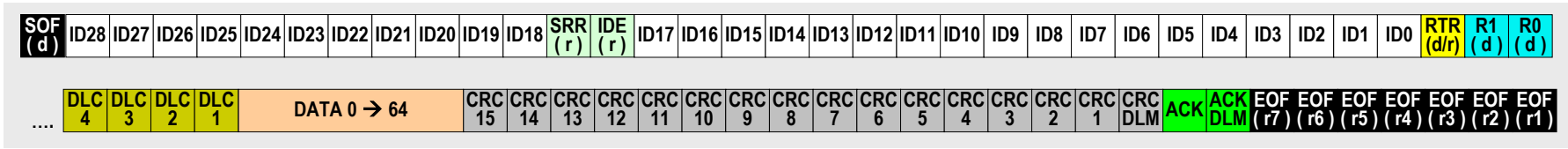
J1939 Communication Protocol



J1939 – Complete definition of a high speed communications network to support real-time closed loop control functions between electronic control devices which may be physically distributed throughout a vehicle.

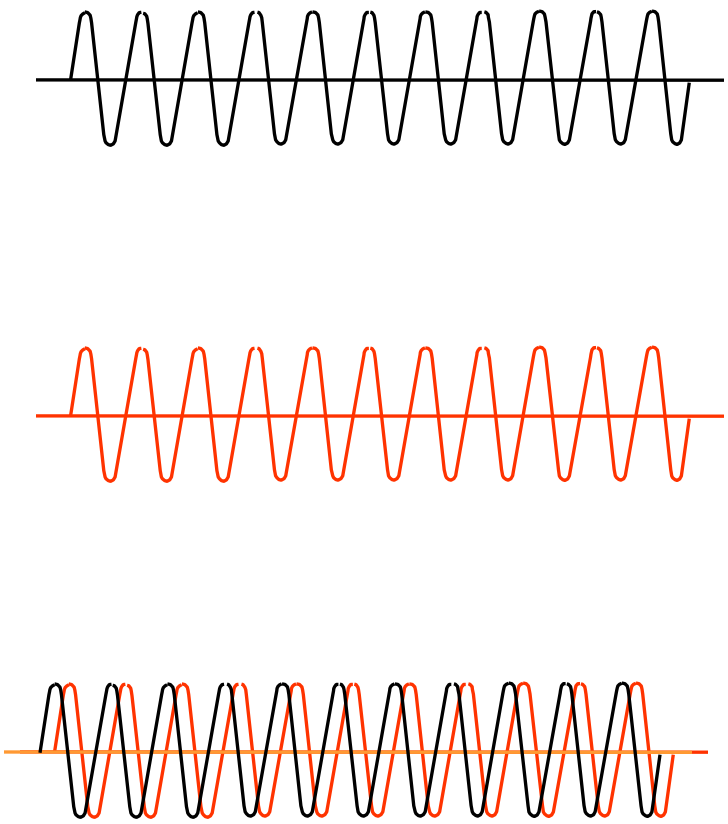
CAN provides a great deal of robustness in terms of getting information from one place to another; however, it provides little definition as to the content.

J1939 *defines, refines or restricts* the generic capabilities of CAN data frames:

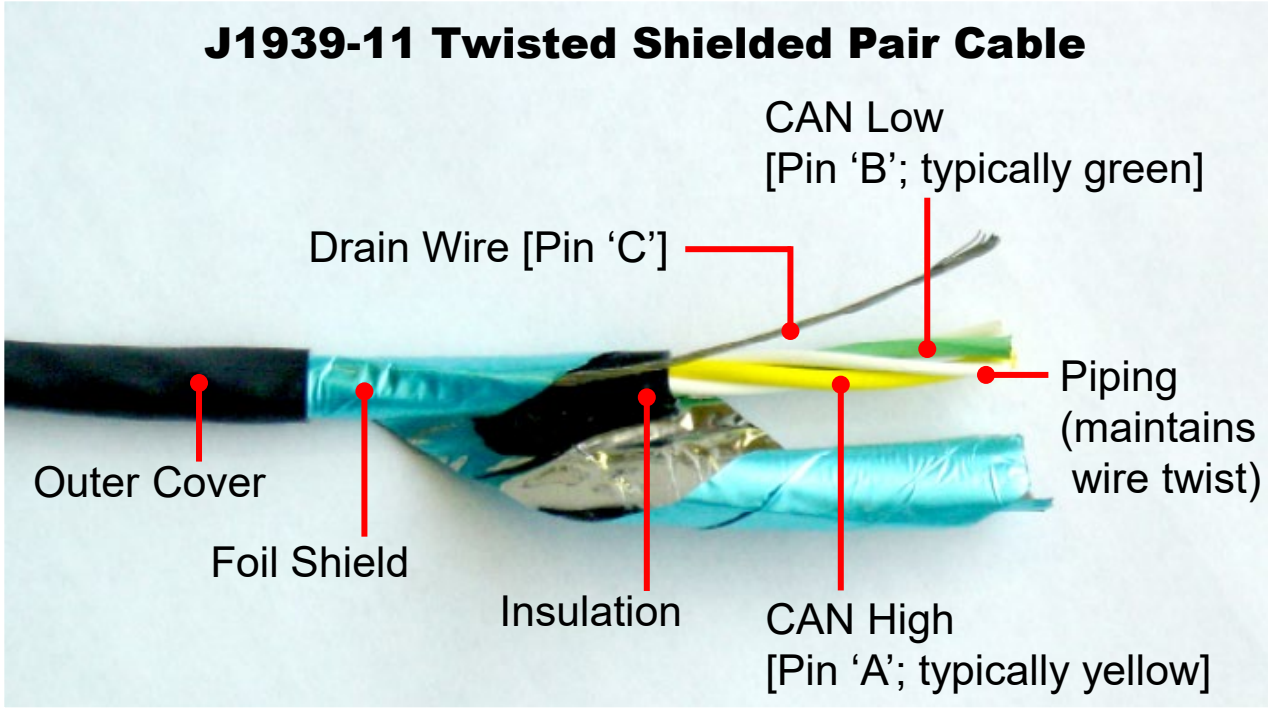


J1939 Twisted Pair Wiring

- Twisted pair wiring consists of two wires twisted together
- This twisting, helps to cancel out magnetic interference
- The J1939 bus Data Cables consist of one (1) twisted pair group
- The individual wires that make up the twisted pair group are referred to Can H and Can L.
- The remaining wire, provides drain (grounded in the middle of the backbone) if any EMI or RFI overpower the shield



J1939-11 Cable Basics



Gillig uses standard J1939 cabling manufactured by Raychem (now TE Connectivity)

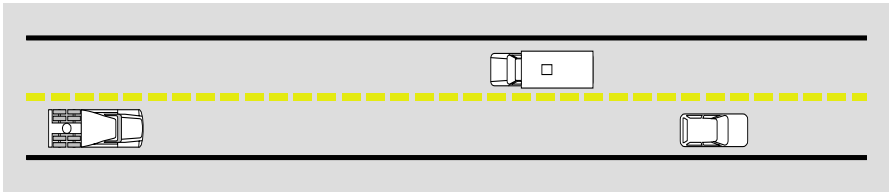
We must also consider cable impedance

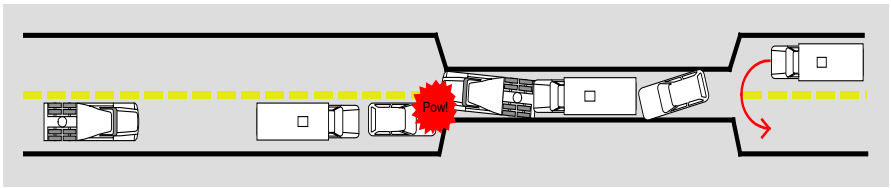
So what's impedance?

Cable Impedance

IMPEDANCE affects the 'the rate of traffic flow' in the wires. It must match the intended volume and rate of traffic. Properly sized, traffic flows smoothly.

If the wrong impedance wire is used, traffic jams and crashes may result. Messages may get lost, or reflect back in the wrong direction.





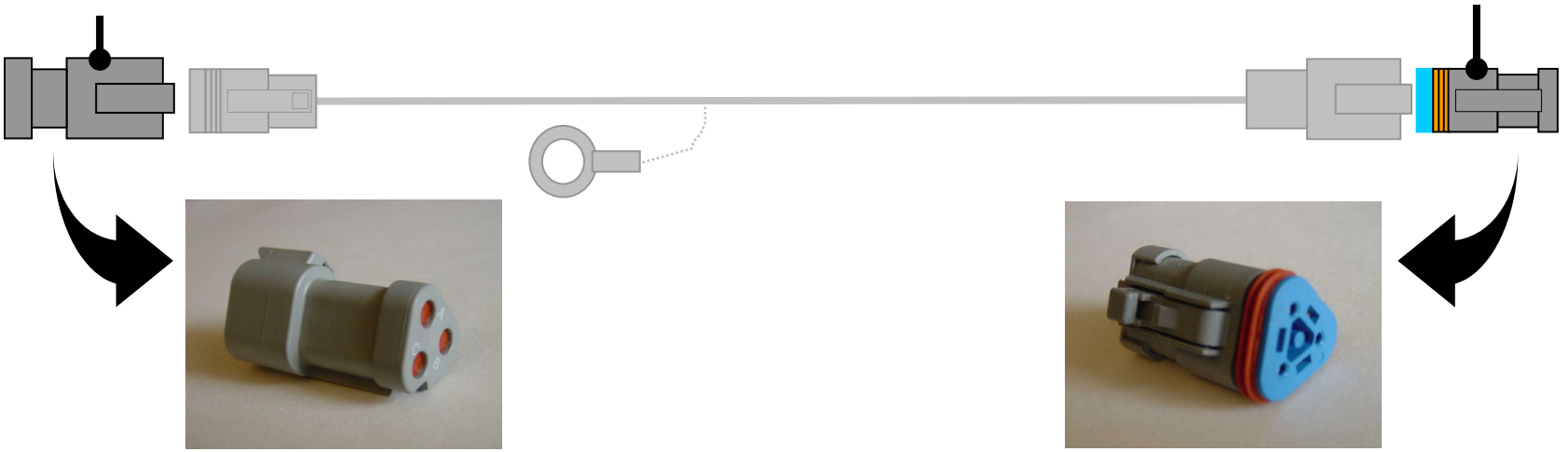
Sources of Impedance Problems

- Mismatched cables; Automotive wire (GPT,GXL,SXL,etc.) will not work!
- Extremely tight bends in the cable
- Long breaks in shielding (if used)
- Separated conductor strands within the cable
- Node spacing on the backbone

Building a specific impedance cable is not intuitive; we leave it to the cable manufacturers!

J1939 Termination Resistors

A TERMINATION RESISTOR is a 120Ω resistor found at each end of the backbone. Two are required, and they typically use **blue wedge locks.**



Some manufacturers build a termination resistor *inside their controller*. These controllers are found at the end of the backbone. Allison GEN IV has this option.

Why are termination resistors required ?

In a word, REFLECTIONS.

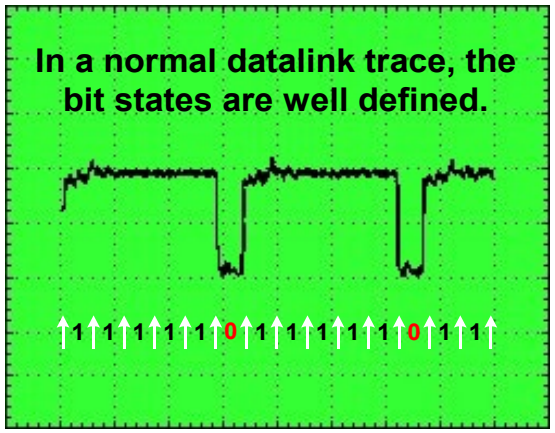
Electricity travels FAST; <671 million MPH.

Reflections happen when fast-traveling pulses reach the end of a cable. It's like waves hitting the side of a pool – smaller waves are reflected back.

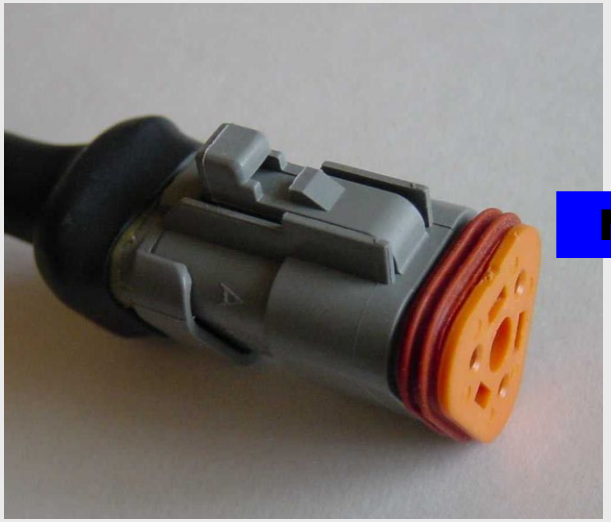
Termination resistors act as 'shock absorbers', keeping pulses from reflecting right back down the cable they came from.

Without proper shock absorbers, reflections bounce around on the datalink and typically cause everything to stop communicating.

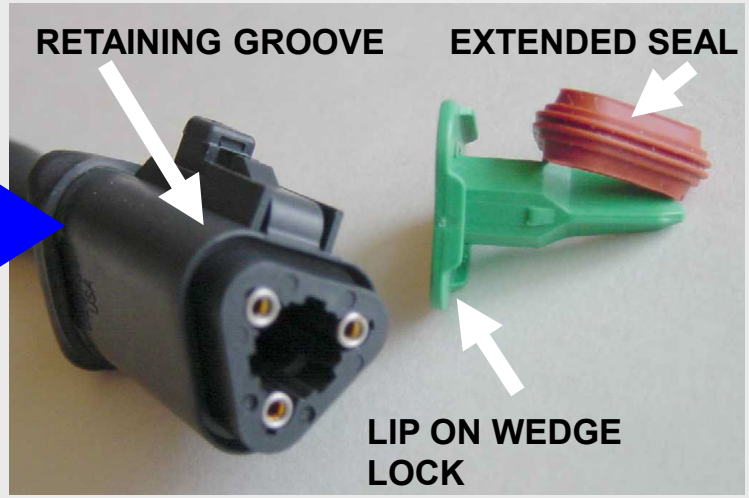
Extremely high bus loading is commonly seen when the termination resistors aren't installed.



Plug Connector Improvements



NEW



On grey plugs, the seal tended to roll off the connector when unplugged.

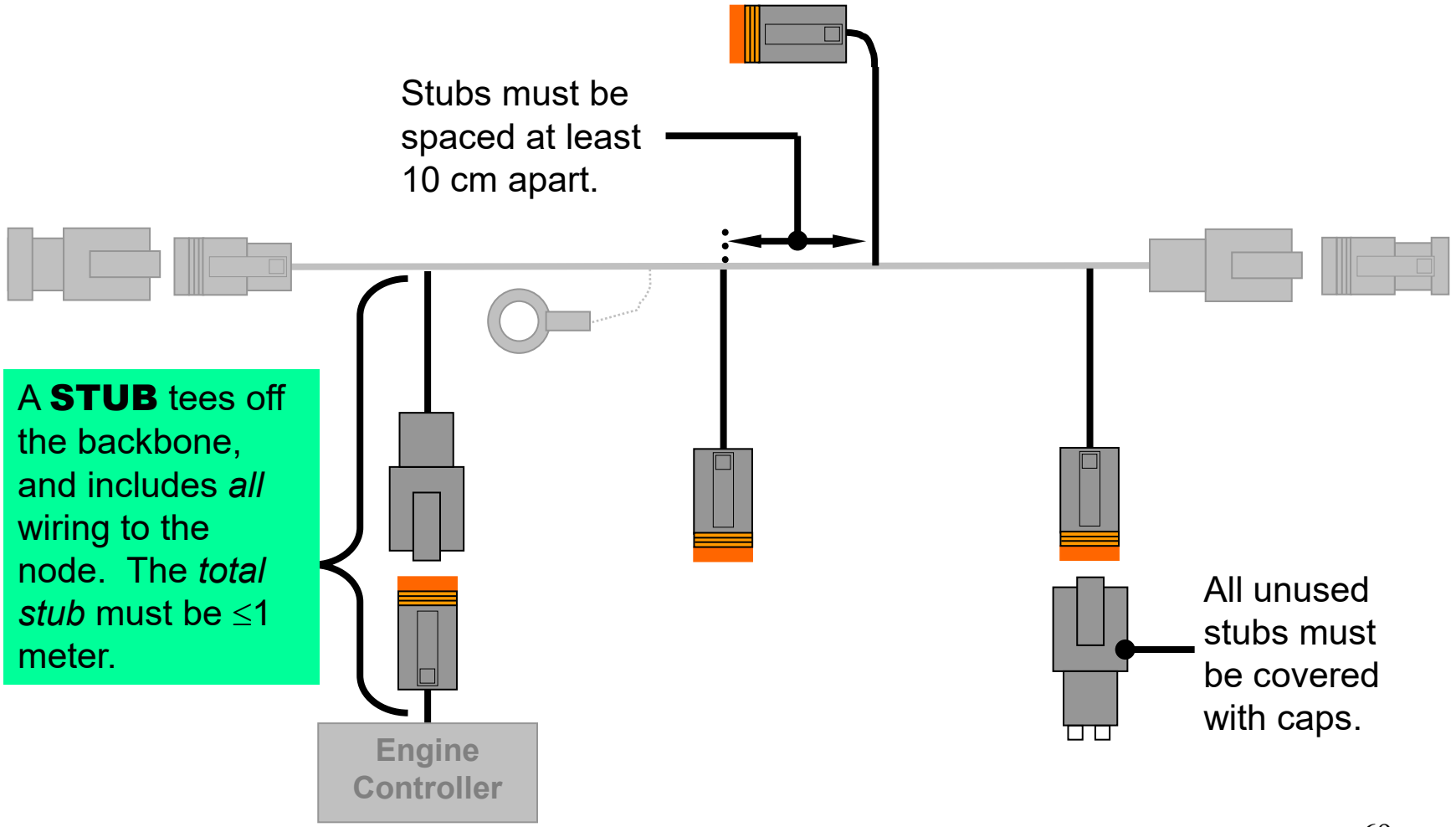
Without the seal, water intrusion can lead to short circuiting of the datalink.

New black plugs designed to capture & lock in the new extended seal.

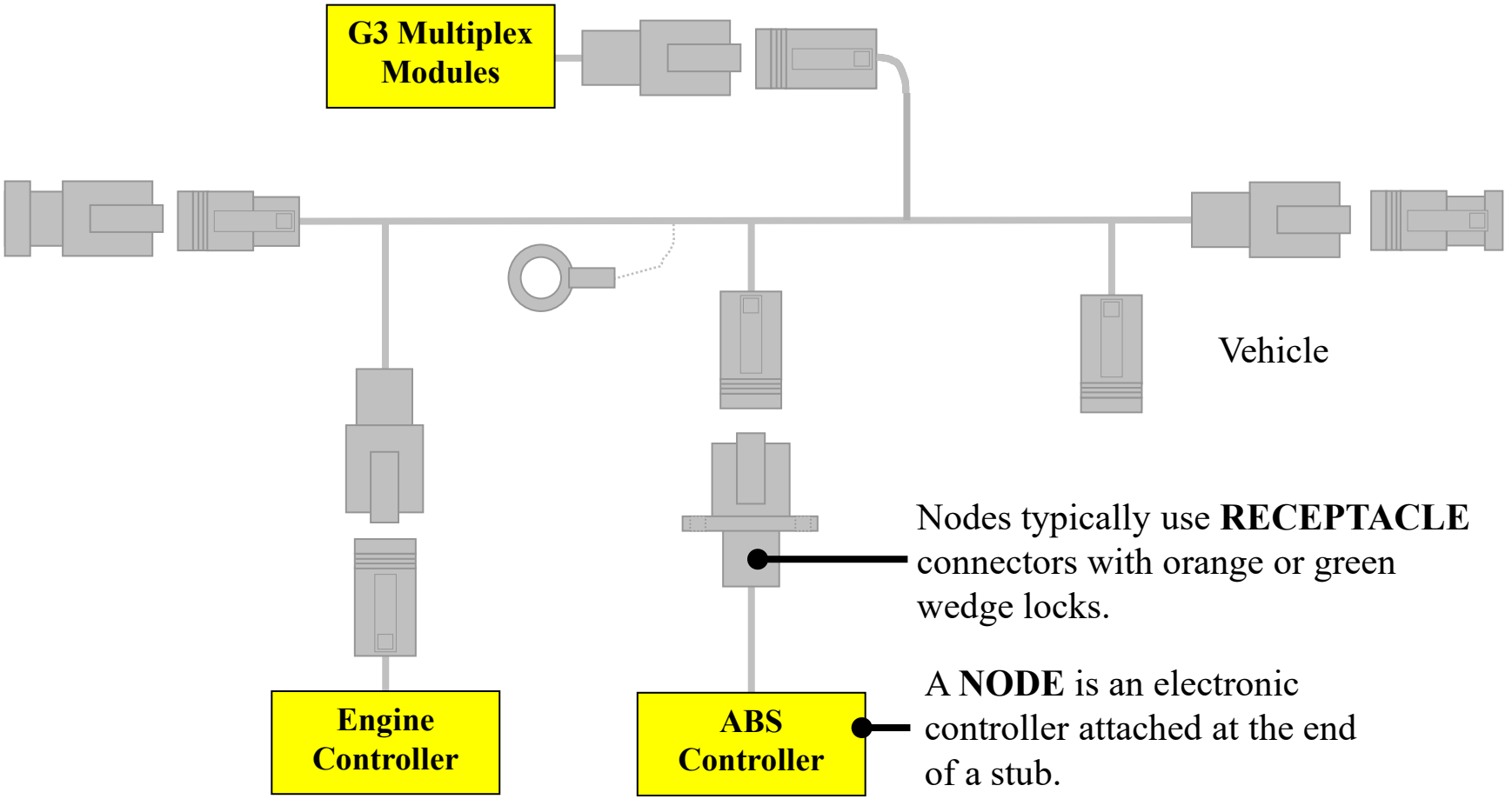
The orange wedge locks have been changed to green.

Components are NOT interchangeable; the correct seals & wedge locks must be used with the correct connector body. However, both plug *assemblies* fit the same receptacle connectors.

J1939 Stubs


Stubs must be spaced at least 10 cm apart.
A **STUB** tees off the backbone, and includes *all* wiring to the node. The *total stub* must be ≤1 meter.
Engine Controller
All unused stubs must be covered with caps.

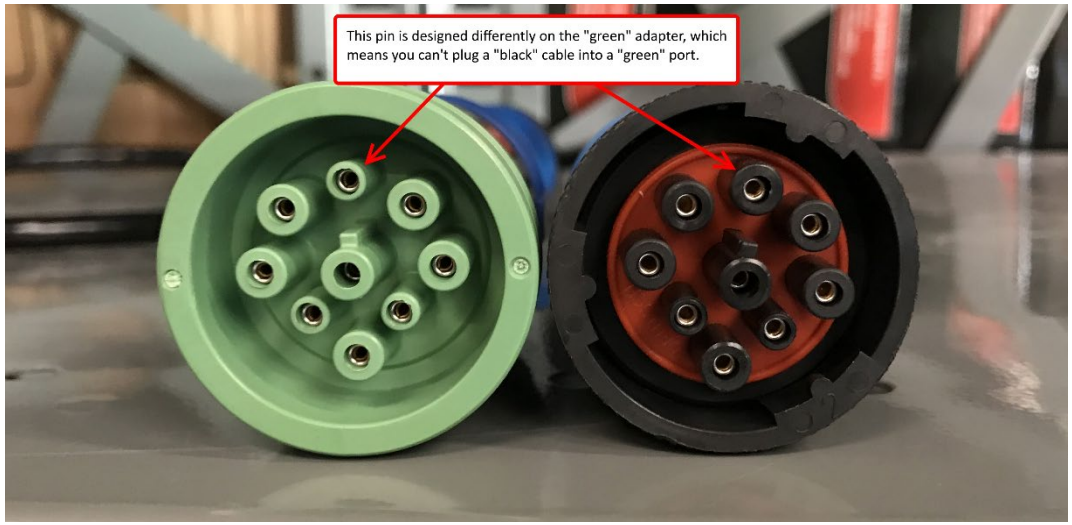
J1939 Nodes



Nodes typically use **RECEPTACLE** connectors with orange or green wedge locks.

A **NODE** is an electronic controller attached at the end of a stub.

Engine, Transmission, ABS J1939-13 Service Connector



12 volt pin must be an **UNSWITCHED** supply! Some vehicle and engine controllers require cycling of the ignition switch during the reflash or reprogramming process. If a service tool loses power during a key switch cycle, the result can be a “locked up” controller that can not be communicated with.

Pin #	Function
A	Battery Minus (Ground)
B	Battery Plus (+V)
C	CAN/J1939 High
D	CAN/J1939 Low
E	CAN/J1939 Shield
F	See Note 1 (Protocol “High” Line, i.e. CAN/J1708/J1939 High)
G	See Note 1 (Protocol “Low” Line, i.e. CAN/J1708/J1939 Low)
H	OEM Defined
J	OEM Defined

9-Pin Deutsch – J1939 “Type 2” for J1939 @ 500k

J1939 Troubleshooting

Step 1 - Check resistance of the data link.

This test checks whether or not both terminating resistors are installed, and ensures that there is a complete circuit from the diagnostic connector through the backbone loop. It does not ensure that branch circuits to each ECU are OK. Tests in this subject are performed using a digital multimeter set to read ohms.

.

IMPORTANT: The ignition must be **OFF** and the Dinex system asleep or powered down prior to any J1939 resistance tests. You may also need to disconnect the batteries to ensure no communication, just make sure you allow time for proper power down. Failure to do so may result in inconclusive resistance measurements. If the reading is not 60 ohms, disconnect batteries and test again.

Connect the meter leads of a digital multimeter, set to read ohms, to pins C and D of the 9-pin diagnostic connector and measure the resistance.

Result	Possible Cause
60 ohms ± 6 ohms	The J1939 datalink backbone is intact and both terminating resistors are installed.
120 ohms ± 12 ohms	Any of the following: • One of the terminating resistors is missing. • One of the terminating resistors is open. • The circuit may be open anywhere between the terminating resistors.
40 ohms ± 4 ohms	Three terminating resistors have been installed; one must be removed. There must be one terminating resistor at each end of the backbone for a total of two.
0 ohms to 5 ohms	J1939+ and J1939- have shorted together somewhere in the system.
Greater than 1000 ohms	The most likely cause is an open circuit between the diagnostic connector and the J1939 backbone. It may also be that both terminating resistors are missing or open.
Any other readings	Any of the following: • Incorrect terminating resistor resistance. • Poor or corroded connections. • Short circuit to ground or an open circuit somewhere on the datalink. Go to step 2 to pinpoint the problem.

J1939 Troubleshooting

Step 2 - Checking for shorts to power and shorts to ground on the J1939 data link.

NOTE: All tests are performed using a digital multimeter set to read dc voltage.
With batteries connected, verify that battery voltage (approximately +12 VDC) is available at pin B of the diagnostic connector. With the ignition ON, use a digital multimeter to test for voltage at pin B by placing the red (+) lead on pin B and the black (-) lead on a good chassis ground (pin A of the diagnostic connector).
Test 1: Test J1939+ for shorts to power and ground.
1. Turn the ignition ON.
2. Touch the red lead to pin B (+12 VDC) and the black lead to pin C (J1939+) of the diagnostic connector.

Result	Possible Cause
0 VDC	J1939+ is shorted to power. Go to Step 3.
12 VDC	J1939+ is shorted to ground. Go to Step 3.
Any other reading	J1939+ is not shorted to power or ground.

Test 2: Test J1939- for shorts to power and ground.
1. Turn the ignition ON.
2. Touch the red lead to pin B (+12 VDC) and the black lead to pin D (J1939-) of the diagnostic connector.

Result	Possible Cause
0 VDC	J1939- is shorted to power. Go to Step 3.
12 VDC	J1939- is shorted to ground. Go to Step 3.
Any other reading	J1939- is not shorted to power or ground. There may be a problem with the vehicle to computerinterface. The datalink itself appears to be OK.

J1939 Troubleshooting

Step 3: Pinpointing Short Circuits On The J1939 data link

These tests pinpoint shorts to power and shorts to ground on the J1939 data link. The tests will indicate on which side of the bus interface the problem exists, the front of the bus or the rear.
NOTE: All tests are performed using a digital multimeter set to read dc voltage.
With batteries connected verify that battery voltage (approximately +12 VDC) is available at pin B of the diagnostic connector. With the ignition ON, use a digital multimeter to test for voltage at pin B by placing the red lead on pin B and the black lead on a good chassis ground.
Test 1: Test J1939+ for shorts to power and ground.
1. Locate the tee connector at the street side rear electrical panel J1939 data link and disconnect it.
2. Turn the ignition ON.
3. Touch the red lead to a +12VDC circuit breaker in the rear electrical panel (+12 VDC) and the black lead to pin A of the three pin Deutsch connector on the end of the cable that comes from the left ceiling harness.

Result	Possible Cause
0 VDC	J1939+ is shorted to power at the front of the bus.
12 VDC	J1939+ is shorted to ground at the front of the bus.
Any other reading	J1939+ is shorted to power or ground at the rear of the bus. Repair as necessary.

J1939 Troubleshooting

Step 3 – Continued
Test 2: Test J1939- for shorts to power and ground.
1. Touch the red lead to a +12VDC circuit breaker in the rear electrical panel (+12 VDC) and the black lead to pin B of the three pin Deutsch connector on the end of the cable that comes from the left ceiling harness.

Result	Possible Cause
0 VDC	J1939- is shorted to power at the front of the bus.
12 VDC	J1939- is shorted to ground at the front of the bus.
Any other reading	J1939- is shorted to power or ground at the rear of the bus. Repair as necessary.

Step 4 - Locating Faults By Circuit Isolation

NOTE: Never cut wires to isolate circuits.
One way to pinpoint a short (steps 2-3) is to isolate it by systematically disconnecting connections on the data link until multimeter indicates the correct measure. You can use the Communication Cable page in the Gillig Electrical Schematics for reference.

If there are no faults in the J1939 data link, the fault exists in a component(s) plugged into the data link. You can begin by disconnecting front and rear gauges from the data link. They only receive messages, so they should not cause any additional diagnostic conditions when unplugged.

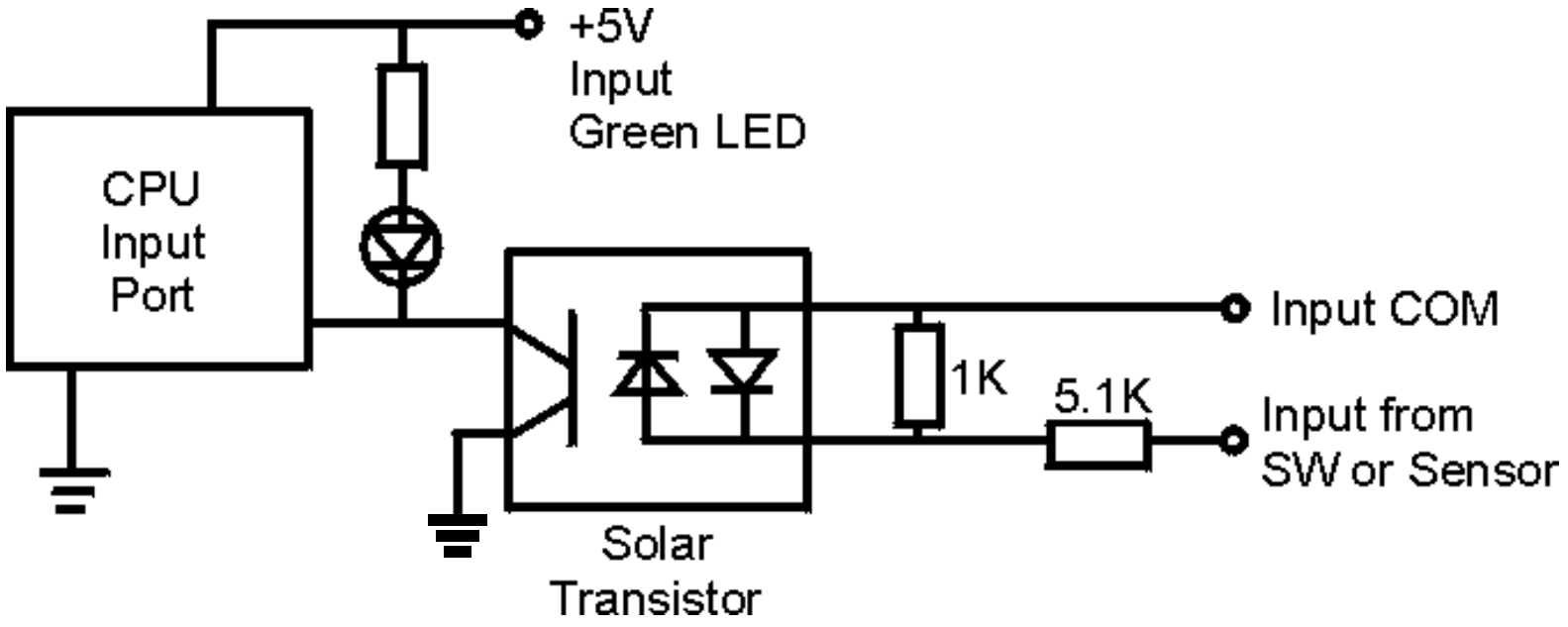
The data link may be shortened by removing one of the end of line resistors and using it to terminate the data link upstream. Confirm with resistance measurement as described in Step 1. Use Communication Cable page in Gillig schematics as reference.

Components in the data link may be removed by unplugging or bypassed with a known good test cable. Depending on the component, you will likely trigger diagnostic malfunction indicators. Once a component is suspect, replace with known good test unit to confirm.

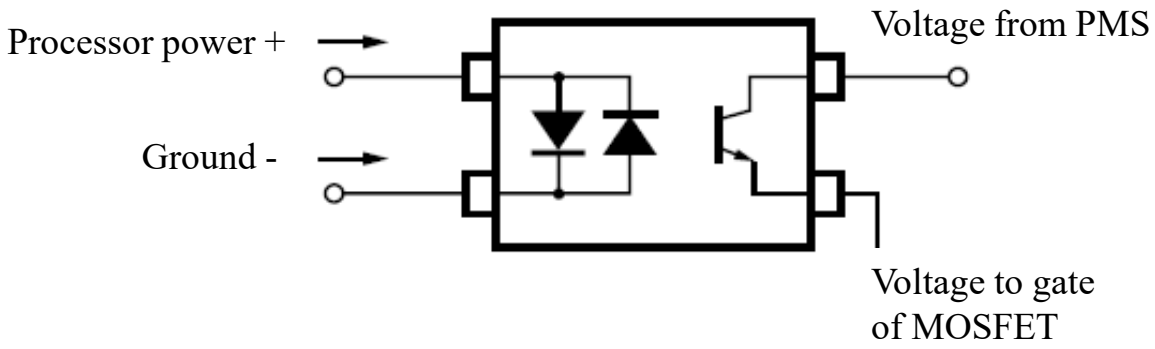
What generates digital signals?

- When any module receives an input, it has one job and one job only – Tell the MBC!
- How does it tell the MBC? It broadcasts a digital message over the Dinex network
- Each module has programming that assigns a digital message to each input at the module CPU
- So, when an input is received, a digital signal is generated by the individual module
- The ground inputs to the CPU itself are provided by phototransistors

Simplified Input Signal Generation



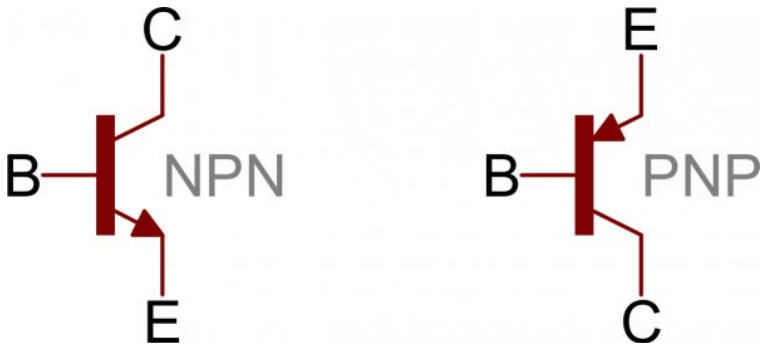
Phototransistors

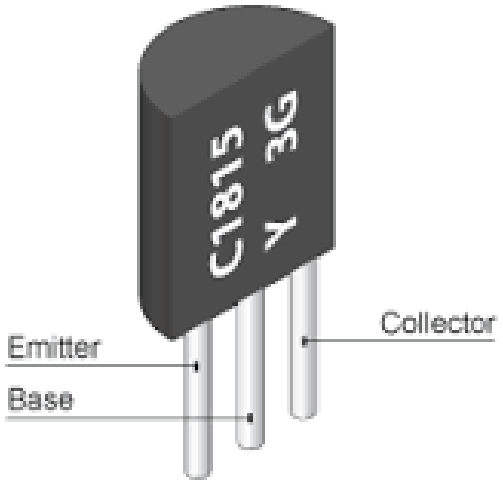


- A phototransistor is a light sensitive device
- A common type of phototransistor, called a photobipolar transistor, is essentially a bipolar transistor in a tranparent case which permits light to reach the base-collector junction
- Dr. John Shive of Bell Laboratories invented it in 1948
- The phototransistor used in Dinex is an NPN type
- This allows the processor to be insulated from the circuit it is controlling
- When the controller activates the LED circuit, photons or light, are what trigger the base of the transistor

BJT Transistors

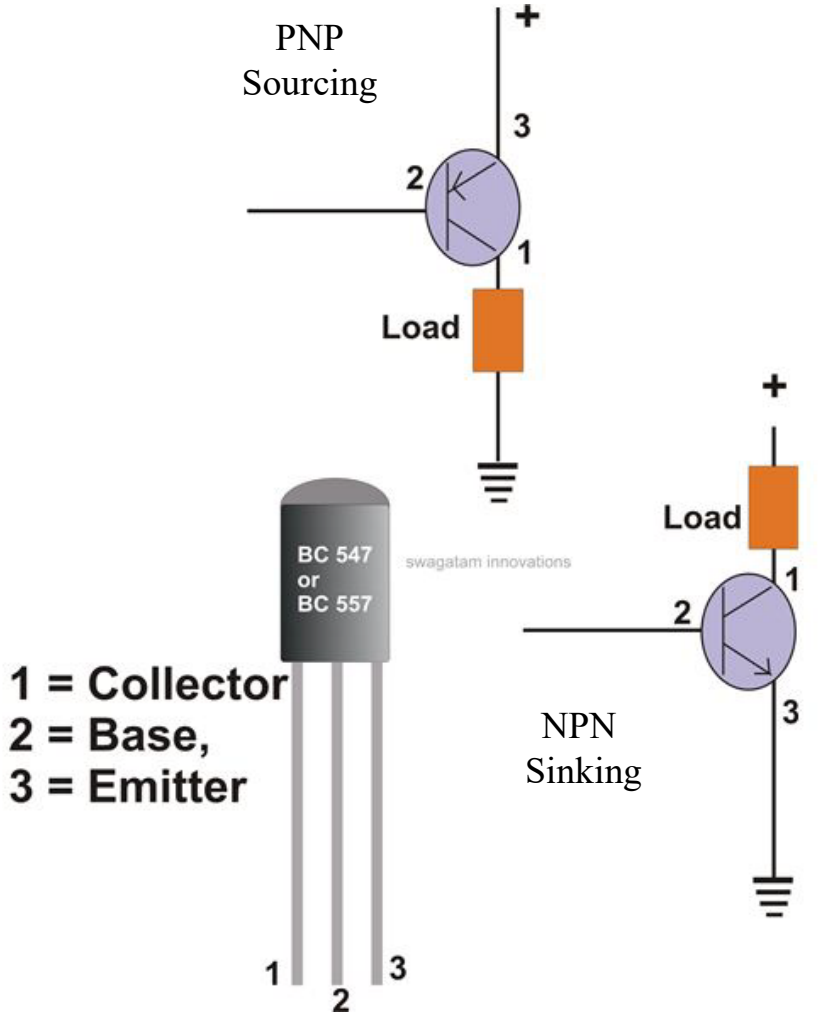
- Dinex Modules use output transistors as electronic switches to control electrical components
- Transistors are semiconductor devices controlled (switched On and Off) by the modules internal CPU
- The term TRANSISTOR is an acronym that came from early days of development and TRANSfer varISTOR
- We will begin our coverage of transistors by discussing the BiPolar Junction Transistor, or BJT
- The basic construction of a BJT is similar to two diodes being connected back to back
- BJT's can only pass current from emitter to collector in one direction





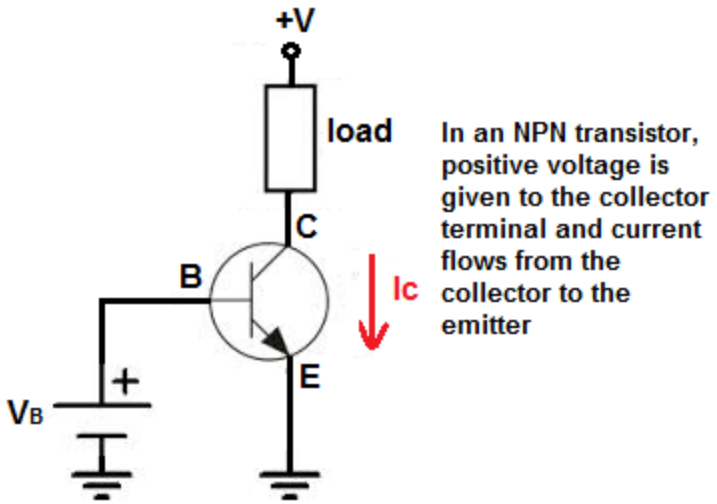
BJT Transistors

- The first BJT was invented in 1947 by Bardeen, Brattain and Shockley of Bell Telephone Laboratories and replaced vacuum tube devices of the early 1900's
- BJT's have three leads:
  - Collector
  - Emitter
  - Base
- There are two types of BJT transistors, PNP's and NPN's



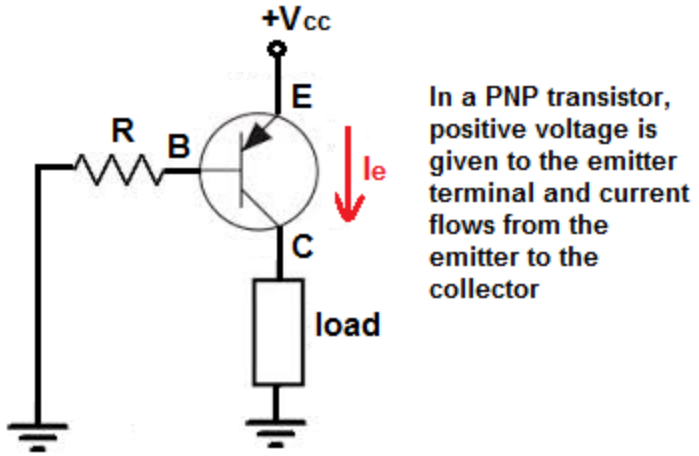
BJT NPN Transistors

- In an NPN transistor current flows from the collector to the emitter
- The load is attached to the collector in this example
- This means that the load has a voltage applied and the transistor grounds the load to turn it ON
- The trigger (or base control) is a voltage
- Without voltage applied to the base, no electron flow or continuity to ground prevents the load from actuating
- With voltage applied, electron flow cascades, grounding (sinking) the load and completing the circuit



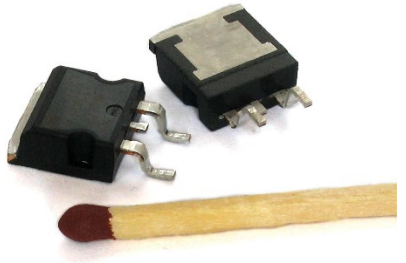
BJT PNP Transistors

- In a PNP transistor current flows from the emitter to the collector
- The load is attached to the collector in this example
- This means that the load has a constant ground and the transistor applies voltage to the load to turn it ON
- The trigger (or base control) is a ground
- Without ground applied to the base, no electron flow or continuity to power prevents the load from actuating
- With ground applied, electron flow cascades, powering (sourcing) the load and completing the circuit

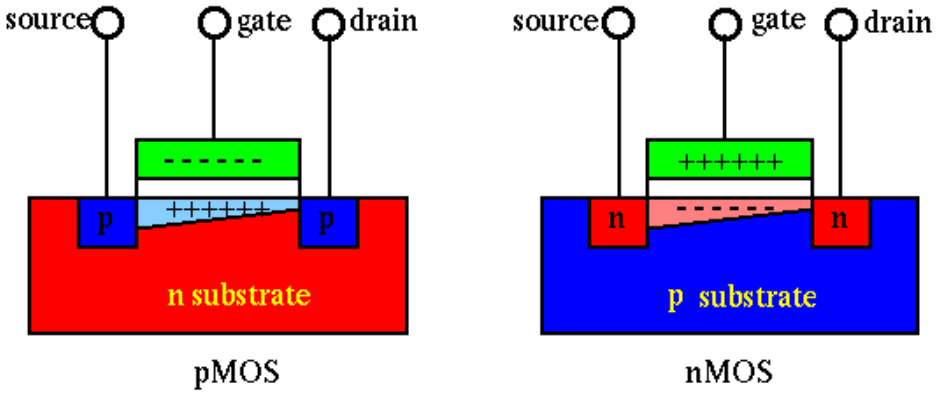


MOSFETs

- The type of transistors used as multiplex outputs are insulated gate field effect transistors (IGFET's)
- The most common type of IGFET is a MOSFET, or Metal Oxide Semiconductor Field Effect Transistor
- Contrary to a BJT, MOSFETS allows the processor to trigger the circuit with little to no current (<1mA), and insulate it from the component circuit it is switching
- The basic principle of the FET was conceived by Julius Edgar Lilienfield in 1925
- The first successful MOSFET was fabricated in the late 1950's, but it took another decade to develop reliable manufacturing processes
- Early forms of the FET used metal (aluminum) as the gate material, but today is more commonly polysilicon (or silicon and germanium SiGe)
- Likewise, the oxide in the term can be a misnomer because different dielectric materials are used that require lower voltages to excite



MOSFETs



- MOSFET's have three main leads:
  - Source
  - Drain
  - Gate

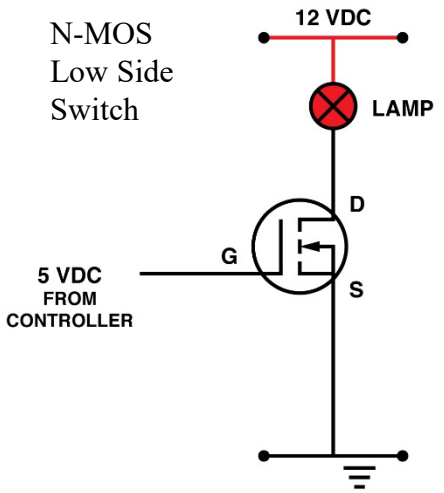
  There is a fourth lead referenced in some illustrations, the substrate or body terminal, but is often connected to the source internally
- There are two modes of MOSFET's, the depletion mode and the enhancement mode.

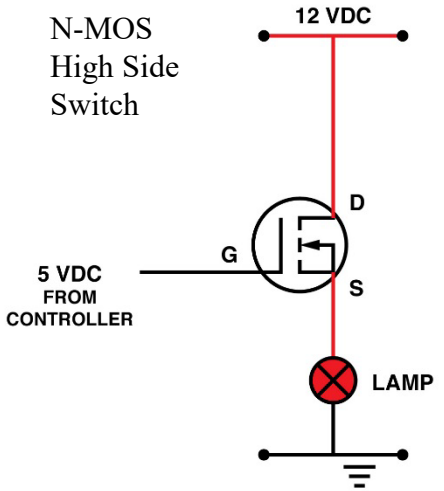
  Depletion – Normally CLOSED

  Enhancement – Normally OPEN
- Each mode is also available as N or P channel type construction.

N-MOSFET

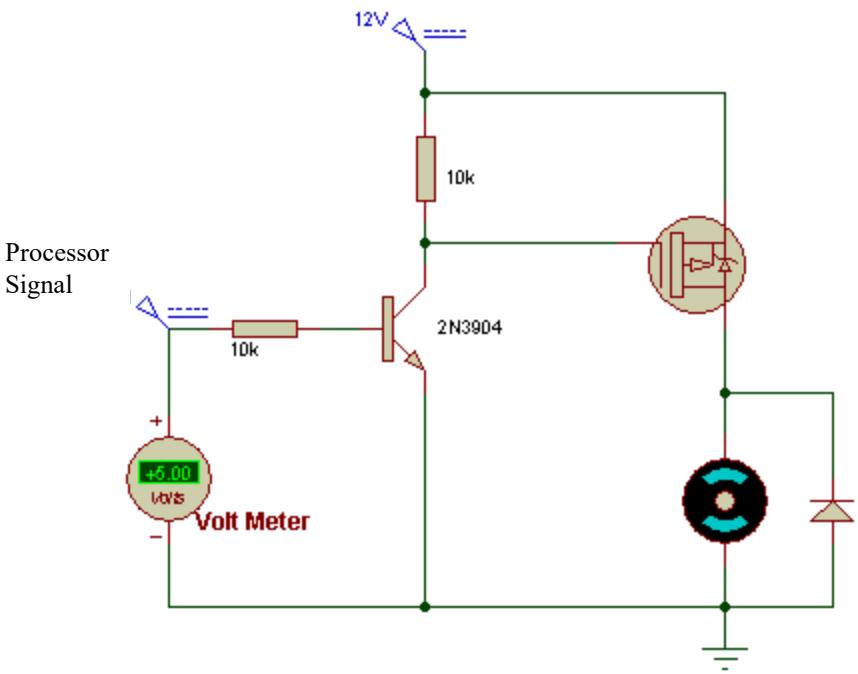
- An N-Channel or N-MOS is the type we will concentrate on because it is the most efficient for our application
- The gate of an N-MOS is triggered with a voltage independent from source pin, 2-4 volts to reach saturation state or ON
- Approximately 0 volts at the gate will turn it OFF
- An N-MOS can be configured with the load placed on the low side or the high side, referred to as low side switch or high side switch
- The most common configuration in a Dinex output is an N-MOS with the load on the high side
- The gate voltage circuit must be isolated from the load circuit in order to trigger with 5 volts, as compared to needing 17 volts
- This is accomplished by using phototransistors





P-MOSFET

- A P-MOS's gate is triggered with voltage drop
- This could be mistaken as a ground, but instead is a lesser amount of voltage (approx. 4 V) than is present at the source to reach saturation or ON. Conversely, it must be roughly the same voltage as the source to be turned OFF
- Usually configured with the same voltage at source and gate with a resistor is circuit to drop voltage
- In this example, the load is attached to the drain
- Not typically used in Dinex



COMM. FAULT LIGHT

- The “Comm. Fault” light is located on the Indicator bar (A1) or MFD
- This fault light gives an indication of a Dinex communication failure using a flash code
- When the Master Switch is turned ON, all indicators come ON for a few seconds, if the Comm Fault light remains ON and blinks, a communication error exists
- Count the blink sequence and compare to the COMM fault light chart located in the Multiplex section of the electrical schematic provided with your bus.

Diagnostic Troubleshooting Steps

1. Observe: Done from driver's seat. Problem found in this step must be corrected before continuing!
    1. Gauges (J1939)
    2. 24V gauge (batteries)
    3. A1 Light Bar (Dinex)
2. Verify Complaint
3. Refer to wiring schematic – Does Dinex control the component with an OUTPUT?
    1. If not, it is not a Dinex problem. Troubleshoot using wiring schematic
    2. If so, continue.
4. Check status of the **output** LED.

Off – Logic problem or open Smart Fuse. Use Diagnose button to check for open Smartfuse

If output LED flashes (after initial 10 sec), the Smartfuse is turning off output. Isolate component/short and repair.

If output LED does not flash, it is a logic problem; use Real Time Monitor or ladder logic process.

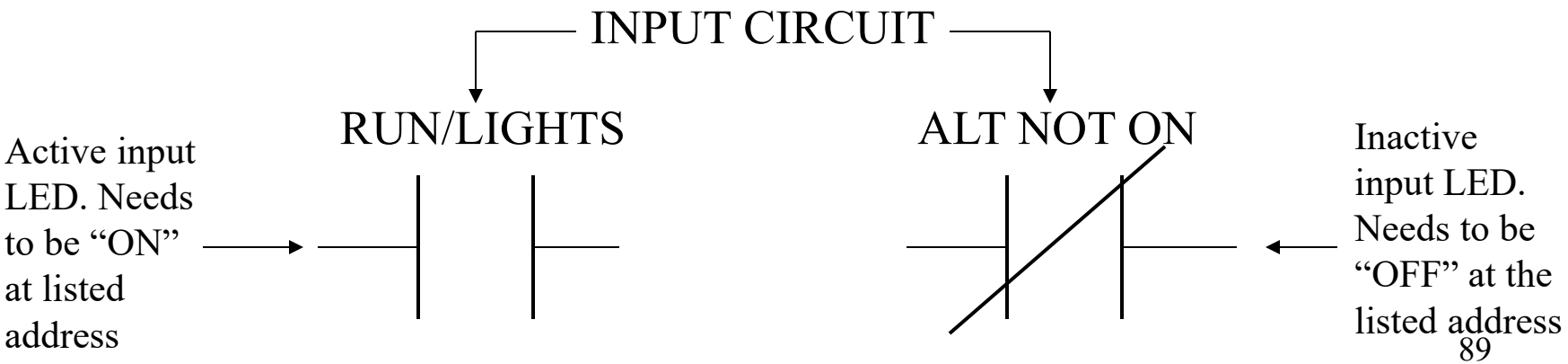
On – Verify output with test light, following the 5 safety steps below before probing:

1. Know the OUTPUT current (ground, 12V or 24V)
2. Test the test light on a known good source of the above current, then set it down
3. Isolate the wire where the output exits the module
4. Verify wire color
5. Verify wire label

- If test light lights up, it is **not** a Dinex problem, diagnose remaining component circuit
- If test light **does not** light up, there are 3 possible causes:
    1. Tripped Smart Fuse (outputs 1-4,15,16)
    2. Supply current is missing
    3. Bad module

Use of Multiplex Ladder Charts

- The ladder charts are used to show all the conditions the Dinex system must see in order to issue the correct digital signals for control
- The ladder charts are critical for system repair and diagnosis
- There are two types of conditional inputs that the system can use ACTIVE INPUTS and INACTIVE INPUTS
- Any reference in the ladder logic to G inputs or outputs are in reference to J1939 information



Typical Ladder Chart Symbols

Input LED must be ON for condition to be TRUE

Input LED must be OFF for condition to be TRUE

OUTPUT, or as a condition, Output LED must be ON for condition to be TRUE

Output LED must be OFF for condition to be TRUE

Flag Function – abbreviation for set of conditions used in multiple outputs

Old symbols for timed functions

New symbol for most timed functions

Kernal or Code Call – programming not visible to us

Ladder Logic Process

1. Go to the page that shows the OUTPUT
   * Ladder logic is organized alpha-numerically, on RIGHT side of page
   * Make a copy – recording the **condition state** can be very helpful

2. Check all **input** conditions first. Record whether the condition was found to be TRUE or FALSE (**condition state**).
   *All inputs come from a switch, sensor or ECM. Switch and sensor failures are the most common cause of logic problems due to failure/adjustment.
   *If the logic is only a single path (AND logic), one condition not being met is enough to prevent the output from being commanded.
   *If the logic is multiple paths, try to determine which path is the path of activation
   *If the problem is an input use the English description to refer back to the **wiring schematics**, looking for a page that shows that specific input. Diagnose the circuit using that information.

3. Check all **output** conditions next, recording TRUE/FALSE (condition state).
   *If the problem is an output, you will need to refer to the logic chart for that output, beginning this process over.

4. Check all **flag functions** by navigating to each one and reviewing conditions
   *Flags are abbreviations for multiple conditions, in the same order, used in more than one output in multiplex
   *There are no LEDS for flag functions like there are for inputs and outputs, so you must look up the specific flag to review conditions
   *Flag functions are left for last because they affect multiple outputs and can have other flags as conditions, making them cumbersome (RTM is a huge help here)