AN1230

SAE J1708/J1587 Communications with the EUSART

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INTRODUCTION

The Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) was developed to address the demands created by higher clock speeds and automotive low-speed networks. The EUSART is found on many PIC® microcontrollers. PIC16F688 will be used for the examples in this application note. This document demonstrates the EUSART used to communicate on an SAE J1708 data bus, such as those found in a modern heavy truck.

FEATURES

The features of the EUSART are as follows:

- Selectable 16-bit Baud Rate Generator mode
- Interrupt on Sync Break character received
- 12-bit Break character transmit
- Auto-baud calibration on Sync character
- Clock polarity select for Synchronous mode
- Transmit polarity select for Asynchronous mode
- Receiver Idle flag
- Receive Shift register empty Status bit during Sleep

Further Reading

Additional information can be found in the data sheet for PIC16F688, the SAE J1708 and the SAE J1587 specification.

Note:	Any microcontroller with an EUSART is suitable for this application note. Appropriate changes must be made to adapt the software from PIC16F688 to a different device.

INTRODUCING J-1708

History

The J1708 serial communications link specification was issued by SAE in 1986. It is intended to describe a hardware and protocol to standardize the communications between modules in heavy-duty vehicle applications. The objectives of the link are:

- Minimize hardware costs and overhead
- Provide flexibility for expansion and advancements without impacting existing systems
- Utilize standard hardware
- Be electromagnetically compatible with the rest of the vehicle
- Provide flexibility for suppliers to customize the link for proprietary reasons

The J1708 link is a bidirectional communications link which links electronic modules that contain microcomputers. The actual J1708 specification defines hardware and the protocol requirements to maintain the link. The actual data that is communicated on the link is defined by a separate J1587 document.

Today, the J1708 data bus is alive and well in heavy trucks. It is used to communicate general status information between electronic modules. A federal requirement for the trailer anti-lock braking system to light a fault lamp in the tractor has led to the development of a power line carrier version of the J1708 data bus. The hardware interface is changed to allow communications over the 12V DC power bus, but the protocol and communications timing remain the same.

J1708 Overview

J1708 is a simple multi-master bus interface built upon a USART peripheral in a microcontroller. While any wired-or type physical layer works with J1708, the specification describes a physical layer based upon an RS-485 bus (see Figure 1). By using a recessive state and a dominate state for the bus, multiple masters can share the transport media without fear of contention. The J1708 protocol includes methods for claiming the bus, resolving collisions, and transmitting data. The data is transmitted at 9600 baud with 1 Start bit, 8 data bits and 1 Stop bit. The packet length is 2 to 21 bytes including a checksum for error detection. Parameter Identification (PID) numbers identify the data on the bus. Groups of PIDs are reserved for data that are of

different lengths. Module Identifiers (MID) identify different transmitters on the bus. The MIDs are numbered to provide an implicit priority scheme. In this way, engine modules get a higher priority than vehicle modules or diagnostic tools.

Additional information concerning J1708 is covered in later sections.

Other Uses

The hardware and software that makes up the basics of a J1708 data bus can easily be used in other applications. A robot could use J1708 and custom messages to share data between multiple CPUs. J1708 can even be used with optical or RF components to create a wireless network. Interfacing a J1708 bus to a PC requires very simple hardware because the PC serial port can understand the data with an appropriate physical layer transceiver.

BASIC J1708 HARDWARE

The SAE J1708 specification describes the basic interface using an RS-485 transceiver. This transceiver is used because:

- It is inexpensive
- It is available
- Despite being used in an unusual way, it is adequate for low-speed work

Since the J1708 specification was released, a few companies have released custom silicon designed to simplify J1708 bus interfaces. Maxim and National Semiconductor are two companies that sell a simple J1708 transceiver.

If an application does not require J1708 physical compatibility but you do want to use the techniques with the EUSART, then a CAN or LIN type transceiver may be appropriate.

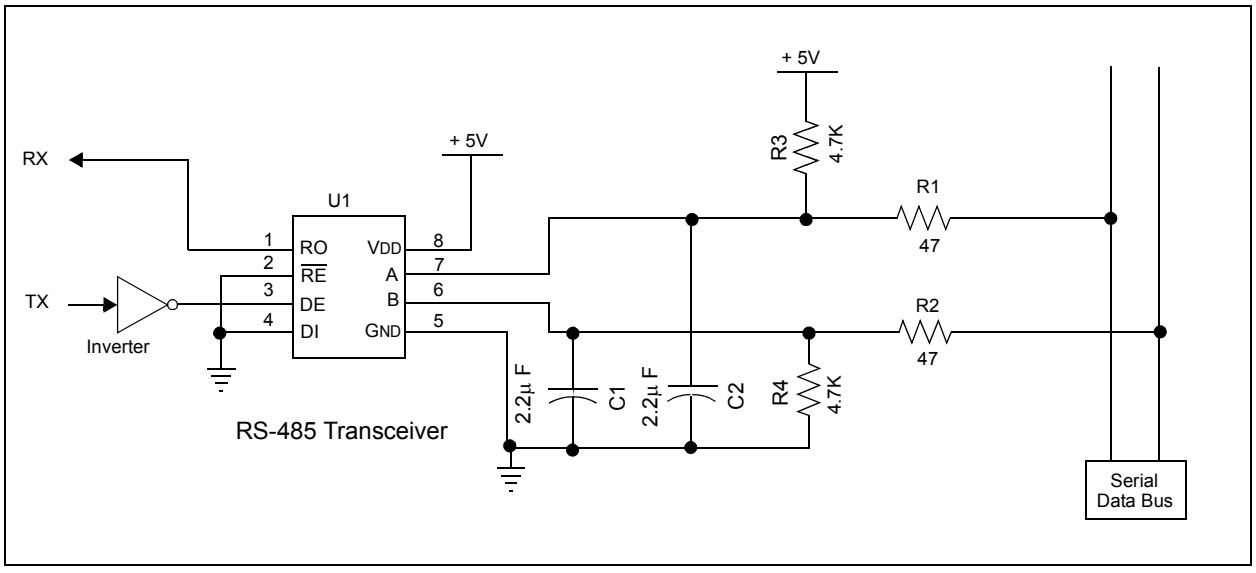
STANDARD J1708 DATA BUS HARDWARE

The standard J1708 node, from the SAE J1708 specification, is shown in Figure 1. This circuit is designed for an RS-485 type bus transceiver. Notice that R1 and R2 pull the bus into the logic 1 state. Notice that the transmit line from the microcomputer (Tx) is driving the data enable (DE) line of the transmitter. Due to the logic state of the transmit enable line, the Tx signal must be inverted before it enters the RS-485 transceiver. On a PIC16F688, this inversion can be handled within the EUSART. The data input (DI) line of the RS-485 transceiver is held at the ground level.

Modulating the enable line and using pull-up resistors eliminates the possibility of electrical bus contention. Logic 0 will always win a bus collision in this design. The resistors R3 and R4 and the capacitors C1 and C2 are low-pass filters to prevent EMI from causing bit errors at the receiver and prevent EMI causing transients during transmits.

J1708 specifies up to 20 nodes on a bus with a maximum length of 40 meters.

FIGURE 1: STANDARD J1708 NODE



J1708 NETWORK ACCESS

Devices that require access to the bus must perform a process called arbitration.

The steps to arbitration are as follows:

1. Wait for the bus to become Idle.
2. Wait the required priority delay after the Idle period has started.
3. Make sure the bus is still Idle. If the bus is not Idle, go back to step 1.
4. Transmit the device MID on the bus.
5. Receive the transmitted MID and determine that the sent MID matches the received MID.
6. If the match was successful, we have claimed the bus. Send the packet.
7. If the match failed, we lost the arbitration. Continue to step 8.
8. If this was the first collision for this packet, go to step 1.
9. Wait for the bus to become Idle.
10. Wait for a pseudo-random number of bit times (between 0-7).
11. Go to step 3.

The arbitration technique is very simple, but has a few requirements that must be defined.

1. What is a bit time?
2. When is the bus Idle?
3. What are the priority delays?
4. How do we determine the pseudo-random number?

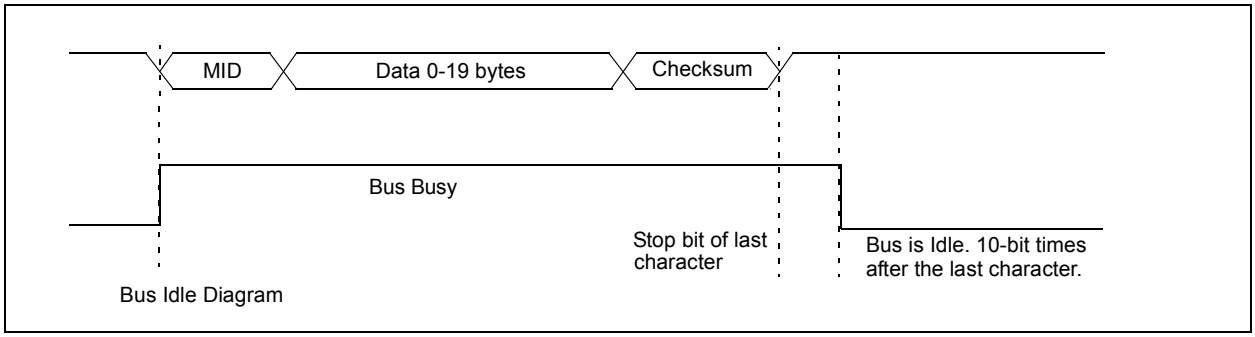
BIT TIME

The bit time is the time required to send 1 bit of data. For the J1708 specification, 1 bit time is 104.16 microseconds. This time corresponds to 9600 baud. All other times specified by the J1708 specification are multiples of bit times.

BUS IDLE

Per the J1708 specification, the bus is Idle after 10-bit times have elapsed from the previous character with no received Start bits. This is very important and must be accurately determined because the J1708 specification defines the end-of-packet condition as the bus going to Idle. After the 10-bit times have elapsed and the receiver is not receiving, then we know the bus is Idle so the previous packet can be validated and any arbitration can continue.

FIGURE 2: BUS IDLE



MESSAGE PRIORITY

All messages on the J1708 bus are assigned a message priority by the defining application document.

The message priority is converted into a message priority delay by the following equation:

EQUATION 1:

$$Pd = Tb * 2 * P$$

Pd = Priority Delay in µS

Tb = Bit time or 104.16 µS

P = Message Priority

Therefore, a message priority of 1 will result in a 2-bit time or 208.32 µS delay from the bus Idle point.

Message priorities are assigned as numbers between 1 and 8. The J1708 specification defines the following classes of message priorities.

TABLE 1: CLASSES OF MESSAGE PRIORITIES

Priority	Message Assignment
1 and 2	Messages that require immediate access to the bus
3 and 4	Messages that prevent Mechanical Damage
5 and 6	Messages that control economy or efficiency
7 and 8	All other messages

PSEUDO-RANDOM NUMBERS

Pseudo-random numbers are used by J1708 to prevent a deadlock condition where two MIDs become synchronized in their attempt to gain access to the data bus. This is most likely to occur if two identical systems are sharing the bus. A robust random number source is not required, but simply a reasonably non-deterministic source of data to prevent the deadlock. Good choices for a PIC microcontroller are:

1. ADC value of a noisy channel,
2. Timer0 LSBs, or
3. Number of bus collisions seen by this receiver.

There are many other possibilities, but these are a good start. The code included in this application note uses a bus collision counter as the random number source for choosing the retry interval.

J1708 DATA FORMAT

The data in a J1708 packet is very simple (see Table 2). The two most critical elements of the packet are the MID and the checksum. The MID is used to identify who is sending the information as well as establish message priority and collision detection. The checksum is required to prevent invalid data from being used. Between the MID and the checksum is the data. Data is preceded by the Parameter Identifier (PID) which informs the receiver of the data type, data size and data scale factor. The J1708 specification establishes the broadcast interval for each PID. After the first PID and its data, additional PIDs can be transmitted one after another until the maximum packet length is reached.

TABLE 2: DATA FORMAT

byte 0	byte 1	byte 2	byte 3 to N (N not to exceed 20)	byte N + 1
MID	PID	Data	Additional PIDs and Data	Checksum

MESSAGE CHECKSUM

The checksum is calculated by adding each packet and subtracting the total from zero. By adding up the data in the receiver, the total should reach zero. If the total is not zero, an error occurred in the data transmission. J1708 does not specify any error correction or data retransmission when a mismatch occurs. The data is simply assumed to be invalid and should be discarded.

Keeping track of the message checksum can provide a useful bus diagnostic. If the checksum is consistently bad it can mean:

1. Another node is behaving poorly.
2. An intermittent connection is disrupting communications,
3. The baud rate is not very accurate, or
4. Electrical interference.

It is very simple to store the checksum mismatch count in the EEPROM of the microcontroller. This data can be reported on request to debug bus problems.

To compute a checksum:

1. add all the bytes
2. invert the sum
3. add 1, and
4. transmit, as the last byte.

Consider the following data.

128	95	23	45	123	XXX

What should be inserted at XXX to assure a proper checksum?

128 + 95 + 23 + 45 + 123 = 158 (assuming an 8-bit adder with an 8-bit result)

Bitwise inversion of 158 results in 97.

Adding 1 yields 99, so XXX should be 98.

The receiver will add all the numbers and expects to see 0.

128 + 95 + 23 + 45 + 123 + 99 = 512 or 0 for an 8-bit sum with an 8-bit result.

This would be valid.

The receiver has two choices after discarding the bad packet, if the data is a regularly scheduled broadcast, the receiver can simply wait for the next broadcast while using the stale data. Or, the receiver can send a request for the data to be resent.

Packet Message Identifier (MID)

The message identifier serves two purposes. The first purpose is to allow a device access to the J1708 bus. To accomplish this function, no two transmitting device on the bus can have the same MID. If your bus must have many similar transmitters, then you will have to allocate a block of MIDs for that function. The second purpose of the MIDs is to create a message priority scheme. See Appendix B.

J1587 defines the data format when the MID is > 127. The J1708 rules still apply, but the data payload is specified.

For example, J1587 extension on J1708 specifies the MID for an engine to be 128. An instrument cluster is assigned MID 140. If both of these devices attempt to gain access to the bus at the same time, the result of the MID collision will be the bitwise AND of the two MIDs (see Table 3).

Notice that the data that ends up on the bus is the same as MID 128. This means that the only device that will see a collision is MID 140. MID 140 will begin the collision retry procedure and will lose because the bus will remain busy until MID 128 finishes sending its data. Once the bus is free again, MID 140 will be able to try again for bus access.

TABLE 3: MESSAGE IDENTIFIER COLLISION ARBITRATION EXAMPLE

	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
MID128	0	0	0	0	0	0	0	1
MID140	0	0	1	1	0	0	0	1
Result	0	0	0	0	0	0	0	1

Payload

The payload of a J1708 packet is a block of up to 19 bytes of data. J1708 does not define a data format for the payload. However, if your MID is ≥ 128, then your payload must conform to the J1587 extension to the J1708 specification. Of course if you are not going live on a real J1708/1587 data bus, then your data format is your own business.

Parameter Identifiers (PID)

When you are using the J1587 extension, your payload data consists of a series of Parameter Identifiers (PIDs) followed by parameter data (see Table 4).

A PID is a one byte number between 0 and 255. The data size associated with a PID is determined by allocating blocks of PID numbers for each required data size. A second page of PIDs is available by using the extension PID 255 (see Table 5). This allows an additional 255 PIDs to be used. A third and fourth page could also be defined by the same mechanism but the current J1587 specification from SAE does not go beyond 1 extension.

All PIDs, after an extension PID, are taken for the next page. If a packet has 3 extension PIDs, then the remaining PIDs will be from page 4.

TABLE 4: PARAMETER IDENTIFIER USAGE

MID	PID	DATA	PID	DATA	PID	DATA	Checksum

TABLE 5: EXTENSION PID USAGE

MID	255 (extension PID)	PID from page 2	DATA	PID from page 2	DATA	Checksum

EUSART and J-1708

Advantages

The EUSART aids in proper J1708 communications by providing a busy bit indicating when the receive state machine is in operation, using a 16-bit Baud Rate Generator for a wide oscillator frequency range and by allowing the transmit pin to be inverted, eliminating an external component.

Library

To simplify the effort involved with creating a J1708 access node, a library was written to perform the low-level task of sending and receiving messages.

The library continuously receives data from the J1708 bus into a pair of buffers. Transmissions to the J1708 bus are scheduled and sent, but they are not queued. The resources used by the driver are shown in Table 6.

TABLE 6: RESOURCES USED BY THE DRIVER

Resource	Used	Purpose
USART	TX and RX IRQ	Data I/O
TIMER0	T0 IRQ	Bus access timer and packet completion detector
GPR	73 bytes	Buffers and working data
Program Memory	332 Words	All driver code

To use the driver to monitor the data bus, simply watch the `j1708_active_buffer` flag for a state change. This flag points to the current buffer in use by the driver. There are two buffers, so the opposite buffer has fresh data. If the flag is set, then the fresh data is stored in `j1708_rx_buffer0`. If the flag is cleared, then the fresh data is stored in `j1708_rx_buffer1`. The number of bytes received into the buffer is stored in `j1708_rx_buffer0_count` or `j1708_rx_buffer1_count`. If the flag, `j1708_checksum_error`, is set, then the last reception had a checksum error. Once it is set by the driver, it stays set until cleared by the application software.

To use the driver to send data to the data bus, simply load bytes into the `j1708_tx_buffer`. Put the number of bytes to send in `j1708_tx_length` and then call `j1708_tx_data`. The function, `j1708_tx_data`, will return as soon as the transmission is scheduled. This does not ensure that the data has been sent. As soon as the transmission is scheduled, the flag, `j1708_tx_busy`, will be set. The application software must monitor this flag. When the flag clears, the transmission has been sent and the transmitter is ready for a new message. Do not modify the contents of the `j1708_tx_buffer` while `j1708_tx_busy` is set.

FIGURE 3: J1708 DATA SEQUENCE

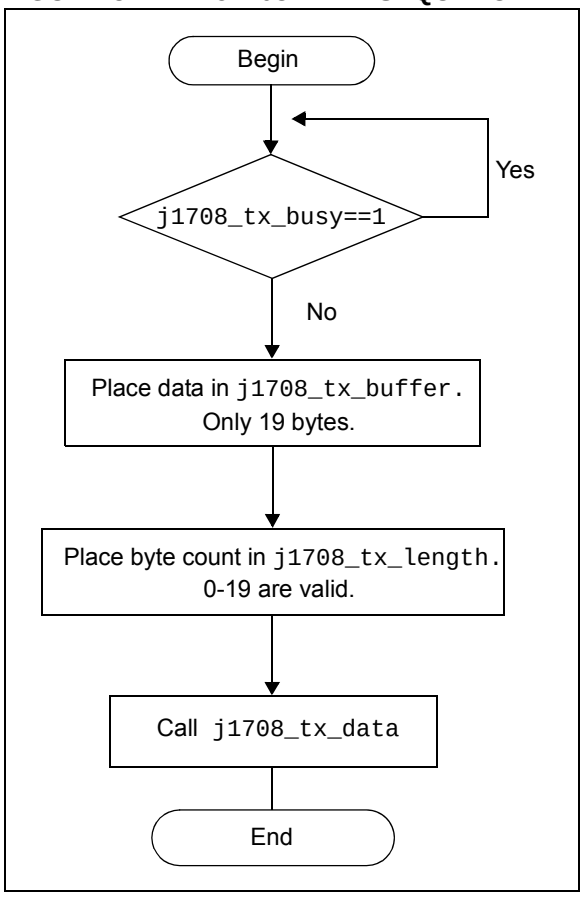
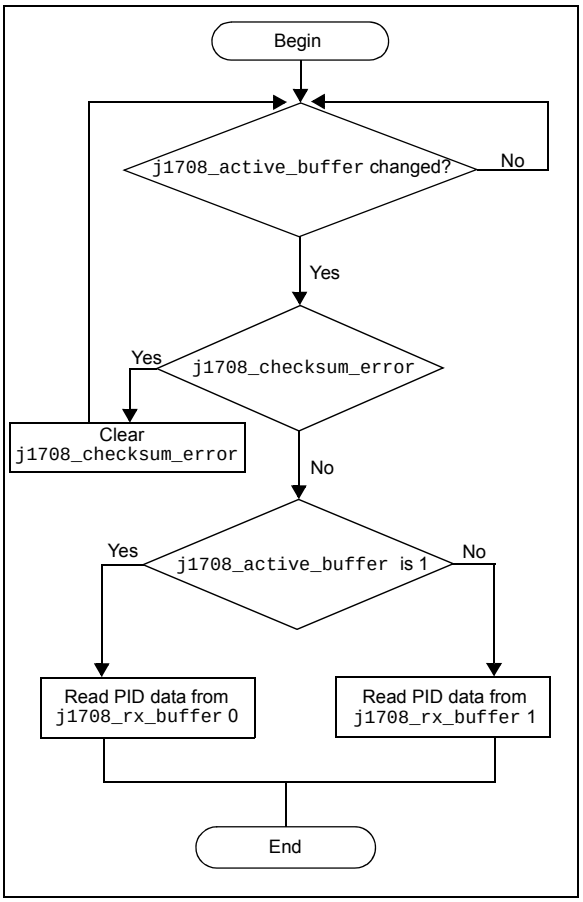


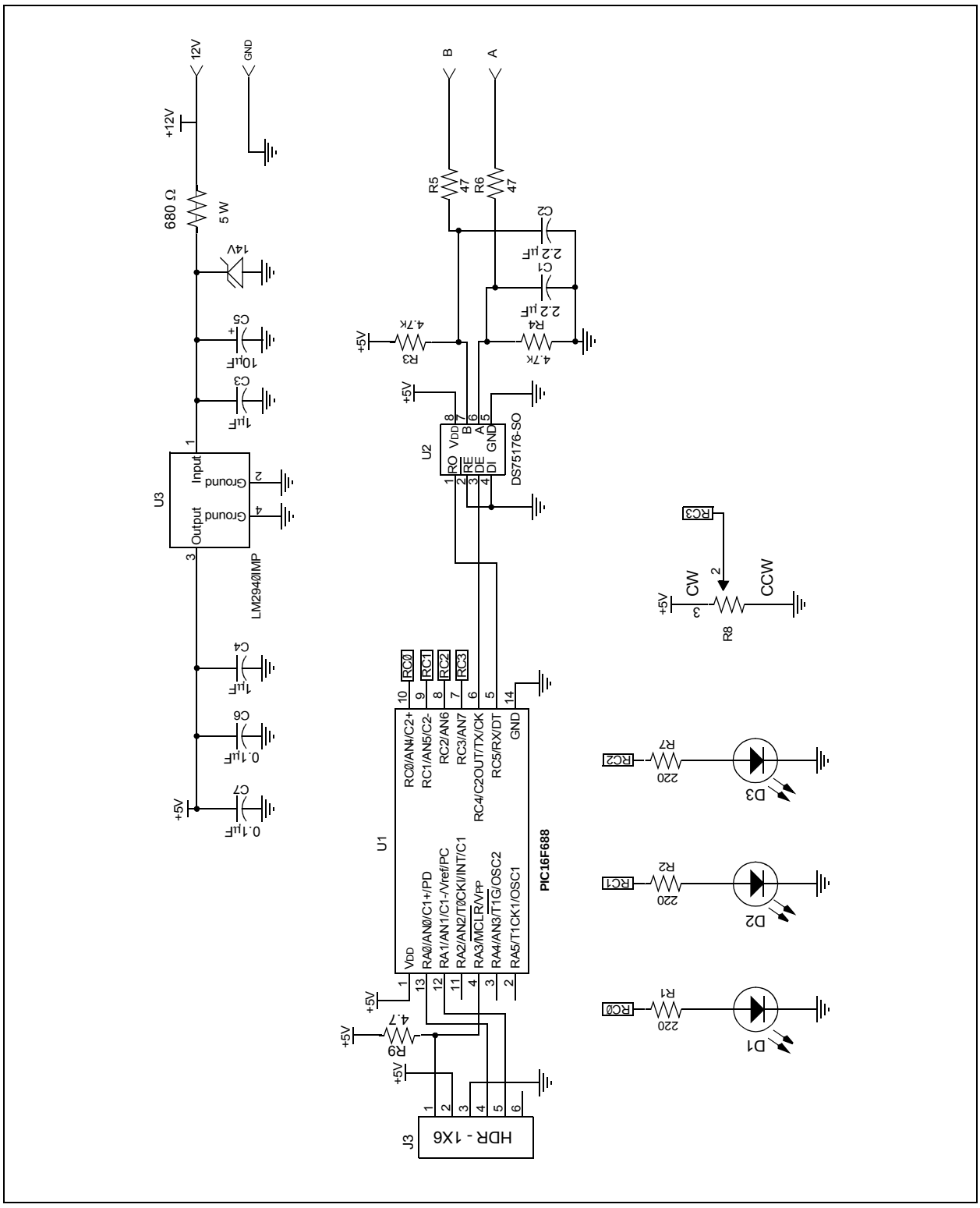
FIGURE 4: J1708 RECEIVE FLOWCHART



CONCLUSION

The J1708/1587 bus is a simple, robust, low-speed, multi-master data bus that has been successfully used in heavy trucking for many years. This bus has many aspects such as low-cost and multi-master that could be useful for other applications. The features of the EUSART and the attached library simplify the task of using J1708 in an application.

APPENDIX A: SCHEMATICS



APPENDIX B: MESSAGE ID ASSIGNMENT LIST

0-127	Defined by SAE J1708
128	Engine #1
129	Turbocharger
130	Transmission
131	Power Takeoff
132	Axle, Power Unit
133	Axle, Trailer #1
134	Axle, Trailer #2
135	Axle, Trailer #3
136	Brakes, Power Unit
137	Brakes, Trailer #1
138	Brakes, Trailer #2
139	Brakes, Trailer #3
140	Instrument Cluster
141	Trip Recorder
142	Vehicle Management System
143	Fuel System
144	Cruise Control
145	Road Speed Indicator
146	Cab Climate Control
147	Cargo Refrigeration/Heating, Trailer #1
148	Cargo Refrigeration/Heating, Trailer #2
149	Cargo Refrigeration/Heating, Trailer #3
150	Suspension, Power Unit
151	Suspension, Trailer #1
152	Suspension, Trailer #2
153	Suspension, Trailer #3
154	Diagnostic Systems, Power Unit
155	Diagnostic Systems, Trailer #1
156	Diagnostic Systems, Trailer #2
157	Diagnostic Systems, Trailer #3
158	Electrical Charging System
159	Proximity Detector, Front
160	Proximity Detector, Rear
161	Aerodynamic Control Unit
162	Vehicle Navigation Unit
163	Vehicle Security
164	Multiplex
165	Communication Unit – Ground
166	Tires, Power Unit
167	Tires, Trailer #1
168	Tires, Trailer #2
169	Tires, Trailer #3
170	Electrical
171	Driver Information Center
172	Off-board Diagnostics #1
173	Engine Retarder
174	Cranking/Starting System
175	Engine #2
176	Transmission, Additional
177	Particulate Trap System
178	Vehicle Sensors to Data Converter
179	Data Logging Computer
180	Off-board Diagnostics #2
181	Communication Unit – Satellite
182	Off-board Programming Station
183	Engine #3
184	Engine #4
185	Engine #5
186	Engine #6
187	Vehicle Control Head Unit
188	Vehicle Logic Control Unit
189	Vehicle Head Signs
190	Refrigerant Management Protection and Diagnostics
191	Vehicle Location Unit – Differential Correction
192	Front Door Status Unit
193	Middle Door Status Unit
194	Rear Door Status Unit
195	Annunciator Unit
196	Fare Collection Unit
197	Passenger Counter Unit
198	Schedule Adherence Unit
199	Route Adherence Unit
200	Environment Monitor Unit
201	Vehicle Status Points Monitor Unit
202	High Speed Communications Unit
203	Mobile Data Terminal Unit
204	Vehicle Proximity, Right Side
205	Vehicle Proximity, Left Side
206	Base Unit (Radio Gateway to Fixed End)
207	Bridge from SAE J1708Drivetrain Link
208	Maintenance Printer
209	Vehicle Turntable
210	Bus Chassis Identification Unit
211	Smart Card Terminal
212	Mobile Data Terminal
213	Vehicle Control Head Touch Screen

Appendix B – Message ID Assignment List (Continued)

214	Silent Alarm Unit
215	Surveillance Microphone
216	Lighting Control Administrator Unit
217	Tractor/Trailer Bridge, Tractor Mounted
218	Tractor/Trailer Bridge, Trailer Mounted
219	Collision Avoidance Systems
220	Tachograph
221	Driver Information Center #2
222	Driveline Retarder
223	Transmission Shift Console – Primary
224	Parking Heater
225	Weighing System, Axle Group #1
226	Weighing System, Axle Group #2
227	Weighing System, Axle Group #3
228	Weighing System, Axle Group #4
229	Weighing System, Axle Group #5
230	Weighing System, Axle Group #6
231	Communication Unit – Cellular
232	Safety Restraint System
233	Intersection Preemption Emitter
234	Instrument Cluster #2
235-255	Reserved – to be assigned

APPENDIX C: J1587 PARAMETER IDENTIFICATION ASSIGNMENT LIST

PID	Parameter
Single Data Character Length Parameters	
0	Request Parameter
1(1)	Invalid Data Parameter
2(1)	Transmitter System Status
3(1)	Transmitter System Diagnostic
4	Reserved – to be assigned
5(1)	Underrange Warning Condition
6(1)	Overrange Warning Condition
7-30	Reserved – to be assigned
31	Transmission Range Position
32	Transmission Splitter Position
33	Clutch Cylinder Position
34	Clutch Cylinder Actuator Status
35	Shift Finger Actuator Status #2
36	Clutch Plates Wear Condition
37	Transmission Tank Air Pressure
38	Second Fuel Level (Right Side)
39	Tire Pressure Check Interval
40	Engine Retarder Switches Status
41	Cruise Control Switches Status
42	Pressure Switch Status
43	Ignition Switch Status
44	Attention/Warning Indicator Lamps Status
45	Inlet Air Heater Status
46	Vehicle Wet Tank Pressure
47	Retarder Status
48	Extended Range Barometric Pressure
49	ABS Control Status
50	Air Conditioner Compressor Clutch Status/Command
51	Throttle Position
52	Engine Intercooler Temperature
53	Transmission Synchronizer Clutch Value
54	Transmission Synchronizer Brake Value
55	Shift Finger Positional Status
57	Transmission Actuator Status #2
58	Shift Finger Actuator Status
59	Shift Finger Gear Position
60	Shift Finger Rail Position
61	Parking Brake Actuator Status
62	Retarder Inhibit Status
63	Transmission Actuator Status #1
64	Direction Switch Status
65	Service Brake Switch Status
66	Vehicle Enabling Component Status
67	Shift Request Switch Status
68	Torque Limiting Factor
69	Two Speed Axle Switch Status
70	Parking Brake Switch
71	Idle Shutdown Timer Status
72	Blower Bypass Value Position
73	Auxiliary Water Pump Pressure
74	Maximum Road Speed Limit
75	Steering Axle Temperature
76	Axle Lift Air Pressure
77	Forward Rear Drive Axle Temperature
78	Rear Rear-Drive Axle Temperature
79	Road Surface Temperature
80	Washer Fluid Level
81	Particulate Trap Inlet Pressure
82	Air Start Pressure
83	Road Speed Limit Status
84	Road Speed
85	Cruise Control Status
86	Cruise Control Set Speed
87	Cruise Control High-Set Limit Speed
88	Cruise Control Low-Set Limit Speed
89	Power Takeoff Status
90	PTO Oil Temperature
91	Percent Accelerator Pedal Position
92	Percent Engine Load
93	Output Torque
94	Fuel Delivery Pressure
95	Fuel Filter Differential Pressure
96	Fuel Level
97	Water in Fuel Indicator
98	Engine Oil Level
99	Engine Oil Filter Differential Pressure
100	Engine Oil Pressure
101	Crankcase Pressure
102	Boost Pressure
103	Turbo Speed
104	Turbo Oil Pressure
105	Intake Manifold Temperature
106	Air Inlet Pressure

Appendix C – J1587 Parameter ID Assignment List (Continued)

107	Air Filter Differential Pressure
108	Barometric Pressure
109	Coolant Pressure
110	Engine Coolant Temperature
111	Coolant Level
112	Coolant Filter Differential Pressure
113	Governor Droop
114	Net Battery Current
115	Alternator Current
116	Brake Application Pressure
117	Brake Primary Pressure
118	Brake Secondary Pressure
119	Hydraulic Retarder Pressure
120	Hydraulic Retarder Oil Temperature
121	Engine Retarder Status
122	Engine Retarder Percent
123	Clutch Pressure
124	Transmission Oil Level
125	Transmission Oil Level High/Low
126	Transmission Filter Differential Pressure
127	Transmission Oil Pressure
	Double Byte Data Parameters
128	Component-specific request
129-134	Reserved - to be assigned
135	Extended Range Fuel Delivery Pressure (Absolute)
136	Auxiliary Vacuum Pressure Reading
137	Auxiliary Gage Pressure Reading
138	Auxiliary Absolute Pressure Reading
139	Tire Pressure Control System Channel Functional Mode
140	Tire Pressure Control System Solenoid Status
141	Trailer, Tag, or Push Channel Tire Pressure Target
142	Drive Channel Tire Pressure Target
143	Steer Channel Tire Pressure Target
144	Trailer, Tag, or Push Channel Tire Pressure
145	Drive Channel Tire Pressure
146	Steer Channel Tire Pressure
147	Average Fuel Economy (Natural Gas)
148	Instantaneous Fuel Economy (Natural Gas)
149	Fuel Mass Flow Rate (Natural Gas)
150	PTO Engagement Control Status
151	ATC Control Status
152	Number of ECU Resets
153	Crankcase Pressure
154	Auxiliary Input and Output Status #2
155	Auxiliary Input and Output Status #1
156	Injector Timing Rail Pressure
157	Injector Metering Rail Pressure
158	Battery Potential (Voltage) – Switched
159	Gas Supply Pressure
160	Main Shaft Speed
161	Input Shaft Speed
162	Transmission Range Selected
163	Transmission Range Attained
164	Injection Control Pressure
165	Compass Bearing
166	Rated Engine Power
167	Alternator Potential (Voltage)
168	Battery Potential (Voltage)
169	Cargo Ambient Temperature
170	Cab Interior Temperature
171	Ambient Air Temperature
172	Air Inlet Temperature
173	Exhaust Gas Temperature
174	Fuel Temperature
175	Engine Oil Temperature
176	Turbo Oil Temperature
177	Transmission Oil Temperature
178	Front Axle Weight
179	Rear Axle Weight
180	Trailer Weight
181	Cargo Weight
182	Trip Fuel
183	Fuel Rate
184	Instantaneous Fuel Economy
185	Average Fuel Economy
186	Power Takeoff Speed
187	Power Takeoff Set Speed
188	Idle Engine Speed
189	Rated Engine Speed
190	Engine Speed
191	Transmission Output Shaft Speed
	Variable and Long Data Character Length Parameters
192	Multisection Parameter
193(1)	Transmitter System Diagnostic Table

Appendix C – J1587 Parameter ID Assignment List (Continued)

194	Transmitter System Diagnostic Code and Occurrence Count Table
195	Diagnostic Data Request/Clear Count
196	Diagnostic Data/Count Clear Response
197	Connection Management
198	Connection Mode Data Transfer
199	Traction Control Disable State
200-223	Reserved – to be assigned
224	Immobilizer Security Code
225	Reserved for Text Message Acknowledged
226	Reserved for Text Message to Display
227	Reserved for Text Message Display Type
228	Speed Sensor Calibration
229	Total Fuel Used (Natural Gas)
230	Total Idle Fuel Used (Natural Gas)
231	Trip Fuel (Natural Gas)
232	DGPS Differential Correction
233	Unit Number (Power Unit)
234	Software Identification
235	Total Idle Hours
236	Total Idle Fuel Used
237	Vehicle Identification Number
238	Velocity Vector
239	Vehicle Position
240	Change Reference Number
241	Tire Pressure
242	Tire Temperature
243	Component Identification
244	Trip Distance
245	Total Vehicle Distance
246	Total Vehicle Hours
247	Total Engine Hours
248	Total PTO Hours
249	Total Engine Revolutions
250	Total Fuel Used
251	Clock
252	Date
253	Elapsed Time
	Special Parameters
254	Data Link Escape
255	Extension

Page 2 Single Byte Data Parameters (modulo 256 value identified in parentheses)	
256(0)	Request Parameter
257(1)	Cold Restart of Specific Component
258(2)	Warm Restart of Specific Component
259(3)	Acknowledgement of Warm or Cold Restart
260–377 (4–121)	Reserved – to be assigned
378(122)	Fare Collection Unit Status
379(123)	Transit Door Status
380(124)	Articulation Angle
381(125)	Vehicle Use Status
382(126)	Transit Silent Alarm Status
383(127)	Vehicle Acceleration
	Double Data Character Length Parameters
384(128)	Component-specific request
385-446 (129-190)	Reserved – to be assigned
447(191)	Passenger Counter
	Variable and Long Data Character Length Parameters
448(192)	Page 2Multisection Parameter
449(193)	Reporting Interval Request
450(194)	Bridge Filter Control
451-499 (195-243)	Reserved – to be assigned
500(244)	Intersection Preemption Status and Configuration
501(245)	Signage Message
502(246)	Fare Collection Unit – Point of Sale
503(247)	Fare Collection Unit – Service Detail
504(248)	Annunciator Voice Message
505(249)	Vehicle Control Head Keyboard Message
506(250)	Vehicle Control Head Display Message
507(251)	Driver Identification
508(252)	Transit Route Identification
509(253)	Mile Post Identification
	Special Parameters
510(254)	Page 2Data Link Escape
511(255)	Page 2Extension

Note 1: These PIDs are superseded by PIDs 194, 195 and 196.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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