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400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE INFORMATION REPORT

SAE J2057/1

Issued 1991-06

CLASS A APPLICATION/DEFINITION

Foreword—The Vehicle Network for Multiplexing and Data Communication Subcommittee has defined three classes of communication networks. Perhaps the least understood with respect to function and implementation is the Class A network. A clear understanding of Class A functions is necessary before any standards for protocol can be established.

1. Scope—This SAE Information Report will explain the differences between Class A, B, and C networks and clarify through examples the differences in applications. Special attention will be given to a listing of functions that could be attached to a Class A communications network.

2. References

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1213—Glossary of Automotive Electronic Terms

2.2 Classification Definitions—The SAE Recommended Practice, J1213, defines three classes of communication networks, Class A, Class B, Class C.

2.2.1 Class A—The Class A network is defined as "A potential multiplex system usage whereby vehicle wiring is reduced by the transmission and reception of multiple signals over the same signal bus between nodes that would have been accomplished by individual wires in a conventionally wired vehicle. The nodes to accomplish multiplexed body wiring typically did not exist in the same or similar form in a conventionally wired vehicle."

2.2.2 Class B—The Class B network is defined as "A potential multiplex system usage whereby data is transferred between nodes to eliminate redundant sensors and other system elements. The nodes of this form of a multiplex system typically already existed as stand-alone modules in a conventionally wired vehicle."

2.2.3 Class C—The Class C network is defined as "A potential multiplex system usage whereby high data rate signals typically associated with real-time control systems, such as engine controls and anti-lock brakes, are sent over the signal bus to facilitate distributed control and to further reduce vehicle wiring."

3. Interrelationship of the Three Classes—A hierarchical relationship exists between the classes of networks. By definition, Class C is a superset of Class B. Also, Class B is a superset of Class A. It should be noted that this is a functional relationship only. Therefore, it is important to distinguish between the function and the application of the multiplex network.

Printed in U.S.A.

3.1 System Speed vs Functional Speed—Most discussions on multiplexing focus on two issues, system speed and system complexity. Confusion arises from associating functional speed with system speed and complexity. As described in 2.2.3, Class C is defined as high-speed and real-time control. Intuitively, high function speed requires high system speeds and perhaps complexity. The Class B definition also makes no reference to the speed of the network or the function but places an emphasis on the type of function, "data communications." Class A defines the functions as being individually wired and not normally connected to intelligent nodes within the vehicle. Here again, no mention is made about the system speed or complexity required to achieve the function. Networks operating at high or medium speeds, therefore, must not be excluded from consideration as a Class A network.

4. Typical Applications of the Classes—Table 1 lists some characteristics of the three classes of multiplex networks. The real functional purpose is shown for each. In addition, the type of information and the timeliness of its distribution is noted.

TABLE 1—CHARACTERISTICS OF MULTIPLEX NETWORKS

	CLASS A	CLASS B	CLASS C
Purpose	Sensor/Actuator Control	Information Sharing	Real-Time Control
Information	Real Time	Occasional	Real Time
Time Window	Wide Window	Varying Window	Narrow Window
System	Multiple Systems	Multiple Systems	System Specific
Information Lost or Corrupted	Nuisance	Nuisance or Failure	Failure

4.1 Class C Typical Applications—Systems that require real-time, high-speed control normally require a significant amount of information to function properly. This information must be available within a narrow time window that cannot vary. A delay of information longer than the specified time window may cause reduced operation or, in extreme cases, could result in the vehicle becoming inoperable. Figure 1 illustrates a Class C application.

4.1.1 EXAMPLES OF CLASS C APPLICATIONS—Anti-lock brakes, steer by wire, traction control.

4.2 Class B Typical Applications—Many systems within the vehicle require information that is common to other systems. While redundant sensors and actuators as well as parallel circuitry would support acceptable operation, multiplex data sharing of this information could result in simpler, more reliable systems. The shared information on a Class B network is not critical to the operation of all of the systems to which it is connected. The delay of a specific bit of information will not cause a critical failure in any of the systems. Therefore, the response window in the Class B network is not nearly as narrow as in the Class C. In fact, the response time may be variable, depending on the application. Another characteristic of Class B network is its interconnection of dissimilar systems. Figure 2 illustrates a Class B application.

4.2.1 EXAMPLES OF CLASS B APPLICATIONS—A typical Class B network could connect engine control modules, body computers, and system diagnostic modules.

4.3 Class A Typical Applications—Figure 3 illustrates the zone locations referenced in Table 2. Tables 2.1–2.4 list typical applications that could be considered for Class A networks. The chart is by no means complete, and will vary from application to application. It serves, however, to illustrate the

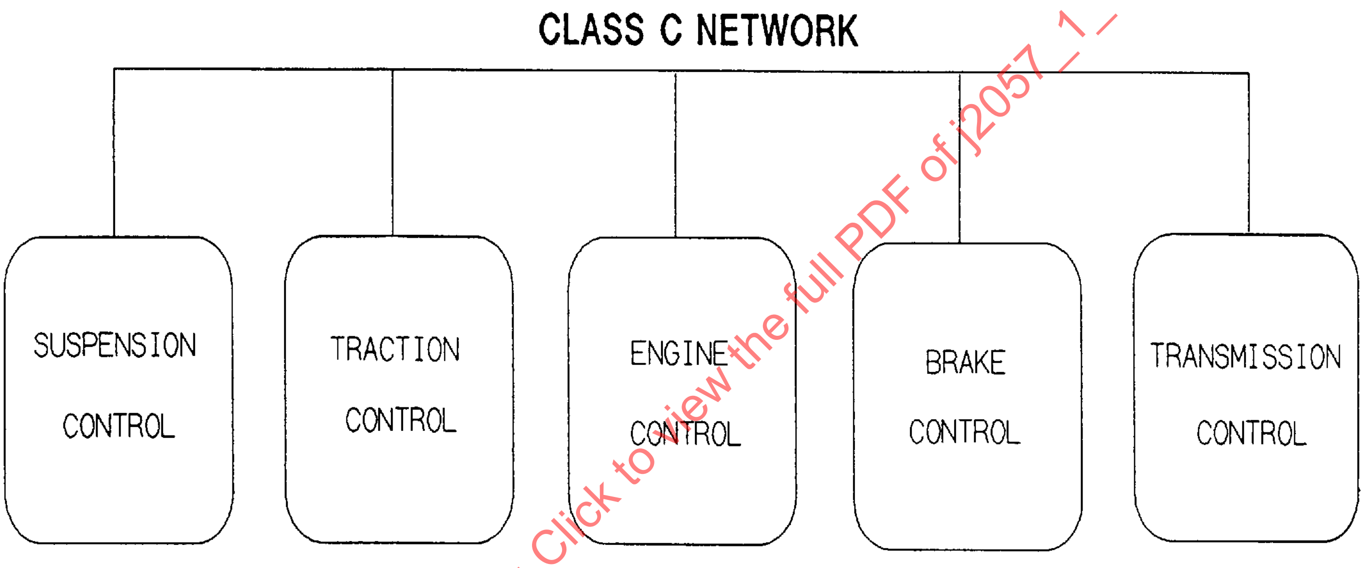

FIGURE 1—TYPICAL CLASS C APPLICATION

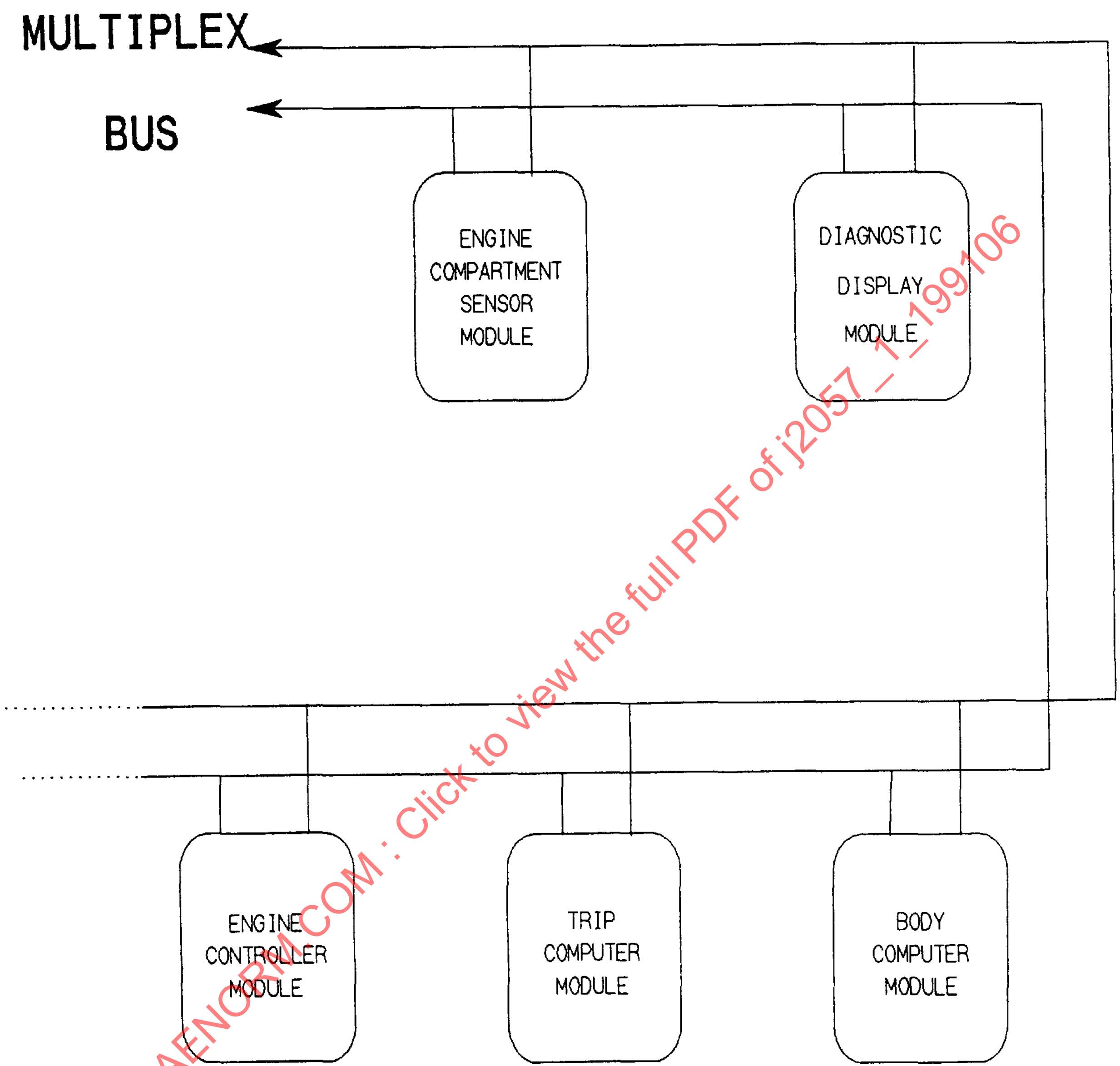

FIGURE 2—CLASS B MULTIPLEX APPLICATION

numerous devices that can be serviced through a Class A network. It contains information on the device type, its anticipated latency requirements, and the severity of damage should the device fail.

TABLE 2.1—TYPICAL CLASS A APPLICATIONS, OPERATOR INPUT SWITCHES

ZONE	DESCRIPTION	LATENCY[2]	TYPICAL[1] NUMBER OF FUNCTIONS	FAULT CATEGORY[3]
2	Headlights	B	2	A
2	Park Lamps	B	2	B
2	Turn Signal	B	3	A
2	Sunroof	C	3	C
2	Trunk Release	C	2	C
2	A/C with 4 Speed	C	10	C
2	Seat Heat	C	2	C
2	Rear Defogger	C	2	C
2	Front Defogger	C	2	B
2	Windshield Wiper	C	2	B
2	Windshield Washer	C	2	B
2	Courtesy Lamps/Overhead	C	2	C
2	Radio Controls	B	12	C
2	Horn	B	2	A
2	Hazard	C	2	A
2	Fog Lamps	C	2	C
2	Fuel Opener	B	2	C
2	Illumination Control	C	2	A
2	Telephone Control	B	20	C
2	Cruise Control (Set.-Res.)	B	4	B
2	Convertible Top	C	2	C
3	Window w/ Lockout & Express	B	14	C
3	Mirror Lt./Rt.	B	7	C
3	Seat w/ Memory	B	12	B
3,4	Vent Window	B	3 EA	C
3,4,7,8	Door Lock	B	3 EA	C
4	Seat SW No Memory	B	9	B
4,7,8	Window	B	3 EA	C
5,6	Recliner	B	3 EA	C
5,6	Lumbar	B	4 EA	C
9	Wagon Rear Window	B	3	B

[1] Typical number of functions will vary with application.
[2] Latency, A: < 50 ms
B: < 100 ms
C: < 150 ms
[3] Fault Category, A: Severe problem interfering with reliable vehicle operation.
B: Problem that is inconvenient to operator but shall be corrected (limp home).
C: Problem that is inconvenient to operator.

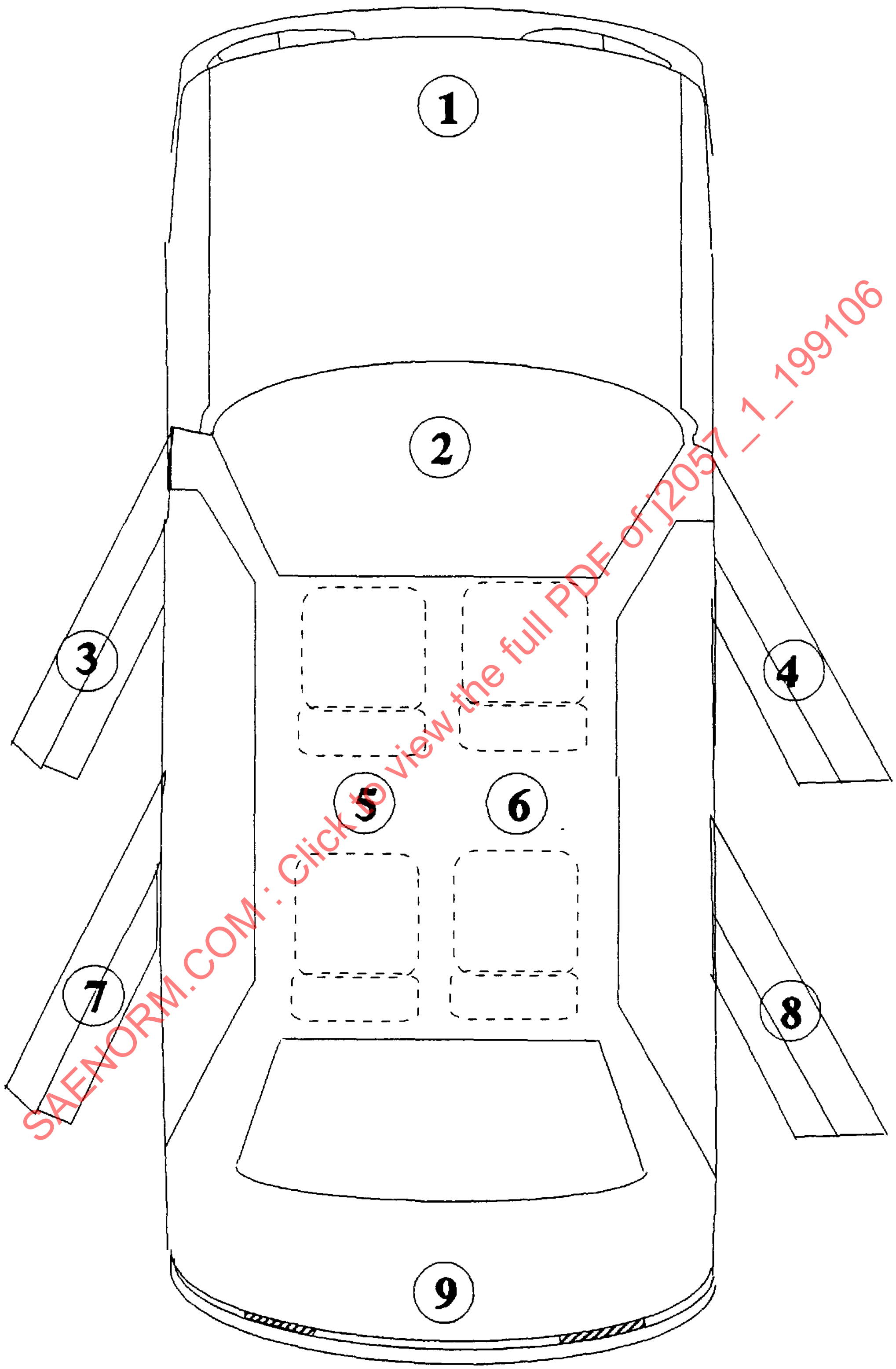

FIGURE 3—APPLICATIONS ZONES

TABLE 2.2—TYPICAL CLASS A APPLICATIONS, INPUT SENSORS

ZONE	DESCRIPTION	LATENCY[2]	TYPICAL[1] NUMBER OF FUNCTIONS	FAULT CATEGORY[3]
1	Hood Latch	C	2	C
1	Rain Sensor	C	2	C
1	Washer Level	C	2	C
1	Brake Fluid Level	C	2	A
1	Engine Oil Level	C	2	C
1	Bat. Cond-Volts	C	2	C
1	Alternator Output-Amps	C	2	B
1	Refrig. Flow	C	2	C
1	Radiator Water Flow	C	2	C
1	Trans. Fluid Level	C	2	C
1	Outside Temp. < Freezing	C	2	C
1	Coolant Temp. Limit	C	2	C
1	Headlight Light Output	C	8	C
1	Blend Door Pos.	C	4	C
1,2	Auto Light Sensor	C	2 EA	C
2	Park Brake Set	C	2	C
2	Brake Pedal Depressed	B	2	A
2	Clutch Depr.	C	2	C
3,4,7,8	Door Lock	C	2 PER	C
3,4,7,8	Door Latch	C	2 PER	A
3,4,7,8	Door Handle	B	2 PER	C
3,4	Window Limit-Express	C	2	C
5,6	Seat Temp.	C	2 PER	C
9	Fuel Level	C	2	C
9	Axle Oil Level	C	2	C
9	Park Lamp Output	C	2	C
9	Stop Lamp Output	C	2	C
9	Auto Level	C	3	C
9	Fuel Door	C	2	C
9	License Lamp Output	C	2	C
9	Trunk Latched	C	2	B

[1] Typical number of functions will vary with application.
[2] Latency, A: < 50 ms
B: < 100 ms
C: < 150 ms
[3] Fault Category, A: Severe problem interfering with reliable vehicle operation.
B: Problem that is inconvenient to operator but shall be corrected (limp home).
C: Problem that is inconvenient to operator.

TABLE 2.3—TYPICAL CLASS A APPLICATIONS, OUTPUT CONTROL

ZONE	DESCRIPTION	LATENCY[2]	TYPICAL[1] NUMBER OF FUNCTIONS	FAULT CATEGORY[3]	STATUS FEEDBACK DESIRED
1	Headlamp	B	2	A	Yes
1	Radiator Fan	C	2	B	Yes
1	Refrig. Flow	C	2	C	Yes
1	Cruise Cont. On-Off	B	3	A	Yes
1	Wipers Hi-Lo	C	2	A	No
1	Horn	A	2	B	No
1	Wind. Wash	C	2	B	No
1,9	Corner Lamps	B	2	B	Yes
1,9	Park Lamp	B	2	B	Yes
1,9	Turn Signal	B	2	B	Yes
2	Defog. Fr.	C	2	B	No
2	Sunroof Motor	C	2	C	No
2	Heater Blower	C	4	B	No
2	Heat Mode Doors	C	4	B	No
2,3,4,7,8	Courtesy Lamp	C	2	C	No
3	Defog Mirror	C	2	C	No
3	Mirror Motors	C	4	C	No
3,4	Vent Window	C	2	C	No
3,4,7,8	Window Motor	B	2	B	No
3,4,7,8	Door Lock	B	2 PER	C	Yes
5,6	Seat Recline Motor	B	8 PER	B	No
5,6	Heated Seat	C	2 PER	C	No
5,6	Lumbar Valves 2 Bag	C	2 PER	C	No
5,6	Lumbar Compr.	C	2 PER	C	Yes
6	Meter Illumination	B	2	B	Yes
9	Conv. Top Motor	C	2	B	No
9	Backup Lamp	C	2	B	Yes
9	Level Control Compr.	B	2	B	No
9	Brake Light	A	2	B	Yes
9	Defog. Rear	C	2	C	No
9	Trunk Rel.	B	2	C	No

[1] Typical number of functions will vary with application.
[2] Latency, A: < 50 ms
B: < 100 ms
C: < 150 ms
[3] Fault Category, A: Severe problem interfering with reliable vehicle operation.
B: Problem that is inconvenient to operator but shall be corrected (limp home).
C: Problem that is inconvenient to operator.

TABLE 2.4—CLASS A TYPICAL APPLICATIONS, ANALOG TO "B" BUS CONTROLLER

ZONE	DESCRIPTION	LATENCY[2]	TYPICAL[1] NUMBER OF FUNCTIONS	FAULT CATEGORY[3]
2	In Car Temp.	C	2	B
2	Wiper Delay	C	2	C
2	Panel Lamp Delay	C	2	C
2	Panel Lamp Dimmer	B	2	B
5	Seat Position	B	3	B

[1] Typical number of functions will vary with application.
[2] Latency, A: < 50 ms
B: < 100 ms
C: < 150 ms
[3] Fault Category, A: Severe problem interfering with reliable vehicle operation.
B: Problem that is inconvenient to operator but shall be corrected (limp home).
C: Problem that is inconvenient to operator.

4.3.1 EXAMPLES OF CLASS A APPLICATIONS—Class A applications include the control of lights, power convenience features, and information diagnostics. Figure 4 illustrates an application of a Class A network.

5. Parameters of Class A Devices—Class A devices can be divided into two main categories, inputs (sensors) and outputs (controls).

5.1 Input Device Definition—An input device is an information-gathering device for other devices or systems. This information can be binary (on or off, open or closed, up or down) or analog (several positions). Examples of input devices are switches and sensors.

5.2 Output Device Definition—An output device does work that causes a desired result. An output device responds to information received from an input device.

5.2.1 OUTPUT DEVICE WITH FEEDBACK (STATUS)—In addition to the requirements of 5.2, these devices also need to communicate information to other nodes. This information is typically associated with the status of the output device, e.g., is it on or off.

6. Class A System Criteria—Many items affect the performance of a Class A network. Depending on the application each item will have a different amount of importance. It is useful, however, to be able to judge each potential Class A system with respect to each of the following criteria. (Refer to Table 3.)

6.1 Latency—For Class A applications, latency is the total time required for a system to respond to a request. This includes the time to sense an input, process the information, and energize the controlled device. This does not include the additional time for the output device being controlled to reach its final state.

6.2 Reliability—This criterion is for the entire system including redundancy of any kind as specified by the system designer.

6.3 Bus and Node Failures—This notes what happens to the operation of the devices on the network in the event of bus or node failures.

6.4 EMC Susceptibility and Radiation—This criterion is for the systems generation of and susceptibility to EMI RFI noise.

6.5 Diagnostics—This is the ability of a system to determine if failures are present in the system and relay this information for appropriate action.

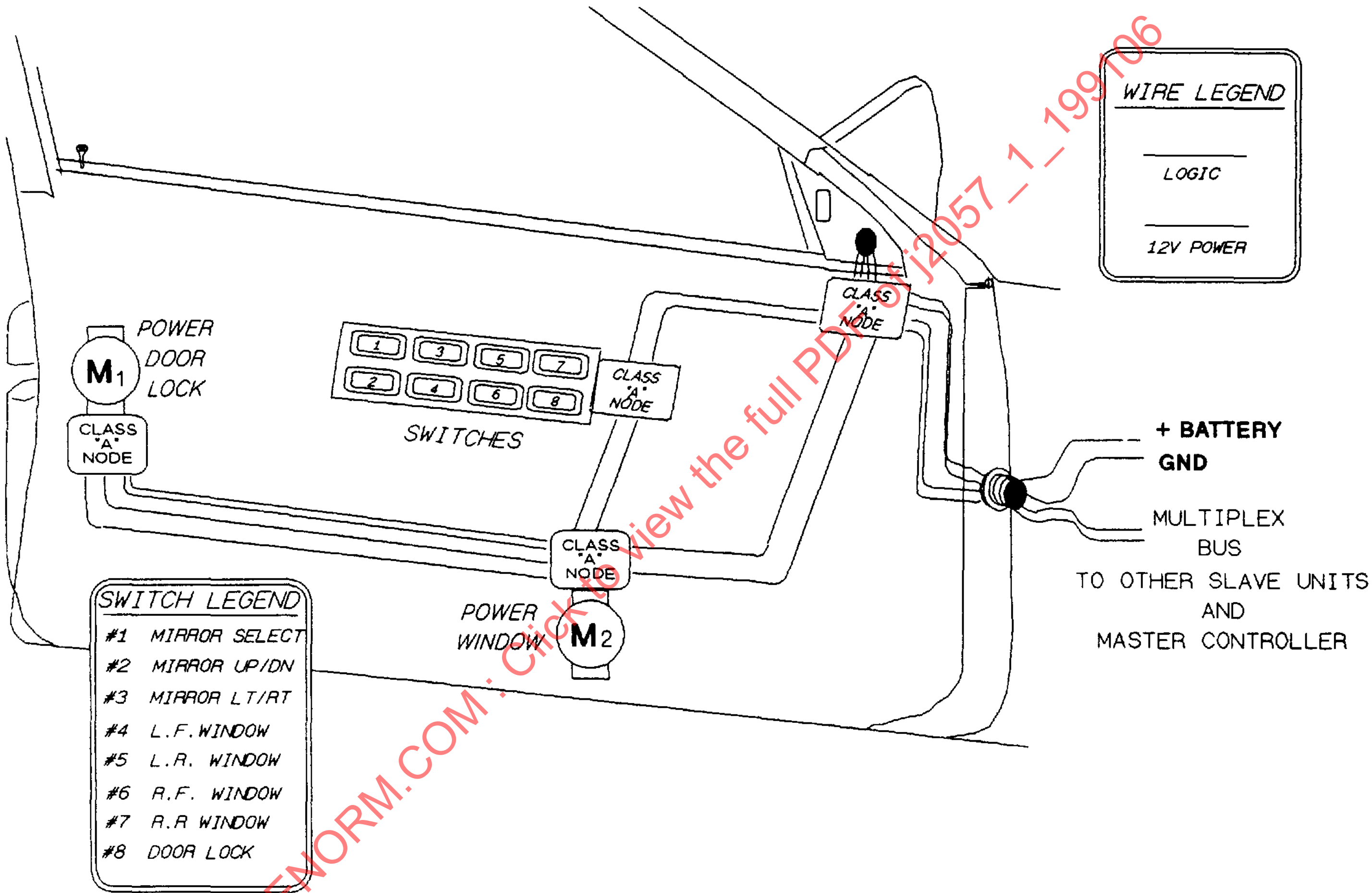

FIGURE 4—CLASS A MULTIPLEX APPLICATION

TABLE 3—CLASS A MULTIPLEX NETWORK CRITERIA

CRITERION	BEST	EXPECTED	LEAST ACCEPTABLE
Latency	< 50 ms	T.B.D.	> 150 ms
Reliability	T.B.D.	T.B.D.	= Non-Multiplexed Systems
Bus Failure	No Effect on Driveability	Limited Effect on Some Functions	Requires Redundancy
Node Failure	No Effect on Function	Function Fails Safe	Function Fails, Other Fcn's not Affected
EMC Susceptibility	30 dBm (Field Strength) Margin over OEM Specs	T.B.D.	0 dBm (Field Strength) Margin over OEM EMC Specs
EMC Radiation	Ambient	T.B.D.	0 dBm (Field Strength) Margin over OEM EMC Specs
Node Diagnostics	Automatic Continuous	Automatic Periodic	Only on Controls Only on Demand
Bus Diagnostics	Automatic Continuous	Self-Regulation	None
Cost	Decrease from Non-Multiplexed System	Same as Non-Multiplexed System	10% Increase Additional Functions
Open System	Public Domain	Free License	License at Minimal Fee
Sensitivity to Environments	Insensitive to Environment	85% of Applications	Separate Networks for Each Car Environment
Communications to Other Networks	Direct Subset of J1850	Via J1850 Micro.	Separate Gateway
Electrical Media	1 Wire & Gnd.	1 Tw. Pr.	Shielded Tw. Pr.
Software Requirements	Central CPU; < 10K	T.B.D.	Distributed > 5K per Node
Node Capabilities	Multiple "I" & "O" per Node	One "I" & "O" per Node	Only One "I" or One "O" per Node
System Capability	> 250 Functions per Network	T.B.D.	64 Functions per Network
Sleep State Current Drain	0 Amps	T.B.D.	= OEM Specs

T.B.D. = To be determined

6.6 Cost—This is the total system cost for the Class A network. It should be relative to the anticipated cost, per function, of a non-multiplexed vehicle.

6.7 Open System—This criterion indicates the proprietary position of the network being evaluated.

6.8 Sensitivity to Environments—This is the measure of the entire system's ability to withstand the various environments within a motor vehicle. It must consider all of the hardware associated with the network.

6.9 Communications to Other Systems—This is the ability of the network to communicate with other networks that are likely to be in the motor vehicle.

6.10 Electrical Media—This defines the requirements for transmission media for the Class A network at the EMI RFI levels specified in 6.4.

6.11 Software Requirements—This is defined as the size of memory required to operate the number of functions indicated in 6.12. Specifications must be given for distributed software as well as a centrally controlled system.