

Chrysler Sensor and Control (CSC) Bus Multiplexing Network for Class 'A' Applications

Foreword—A proprietary multiplexing technique called the Chrysler Sensor and Control (CSC) Bus has been designed which gives the systems engineer an effective means to meet the future demands of automotive customers. The CSC Bus allows the design of the base vehicle, while attaching the complete cost of optional features to the option. This paper will describe the protocol for this CSC Bus multiplexing technique and show that it leads to the simplest vehicle electronic system.

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1. **Scope**—The CSC Bus components defined herein were developed to provide simple, yet reliable, communication between a host master module and its sensors and actuators. The scheme chosen provides the ability to communicate in both polling mode and direct addressing modes.

- 1.1 **Background**—Vehicle applications for multiplexing can be broken into three broad classifications:

- a. Class A - Sensor and Control Multiplexing
- b. Class B - Data Communications
- c. Class C - High Speed Real Time Control

Sensor and Control Multiplexing is the more classical form. An example of this kind would be fluid level sensors, door/hatch switches, and control of the vehicle headlamps, tail lamps, stop lamps, horn, wipers, etc., through a multiplex wiring network. Normally, Control Multiplexing affects the base vehicle wiring system, which directly affects the base cost. On the other hand, Data Communications multiplexing (Class B) interconnects intelligent modules such as the engine controller, body computer, vehicle instrument cluster, and other electronic modules. It normally does not affect the base vehicle wiring but provides an intermodule data communications link for distributed processing and, if properly partitioned, will reduce costs on all but the base vehicle. Finally, there is a class of medium to very fast real time control modules such as the engine controller, automatic transmission, and antiskid controller.

Class B Multiplexing is a very useful technique for reducing the problems encountered by the automotive electronic system engineer. However, in many situations Class B multiplexing leads to a less than optimum system. This Class B Network can be an effective enabler to vehicle integration but it does not solve the sensor and actuator connection problem. After a careful study of the current Class B Network, it was obvious that a different system needed to be developed. Statistically speaking, it was determined that there are approximately seven sensors to every actuator in a potential Class A Multiplex Network. A form of multiplexing which would permit smaller module connectors and reduce the number of wires crowding through the congested areas without introducing more modules is highly desirable. The Chrysler Sensor and Control (CSC) Bus is a style of multiplexing which meets these objectives.

Another problem presented to the System Designer consists of implementing different levels of option content. Base vehicles receive limited electronic feature content, medium vehicles receive some optional electronics, and premium vehicles contain an extensive amount of electronic features. CSC multiplexing has the ability to solve this variable content uncertainty as well as the wiring congestion problem.

- 1.2 CSC A Potential Class A Multiplex Network**—The proposed solution defined herein integrates a multiplexer with a Hall Effect Sensing Element and replace the reed switch used in current sensors. When standard switches are given multiplexing capability they are really sensors. They no longer 'switch' as they do today. Instead they 'sense' some parameter and report back the status including sensor diagnostics. The CSC Bus allows for increased feature content in existing modules by connecting additional sensors. More exotic sensors are also practical using multiple CSC sensors.

Perhaps the biggest factor and criteria of judgment as to whether a Class A multiplexing network will be successful or not is cost. The CSC sensors have been designed to include the multiplex circuit integrated with the Hall Effect Device in the same TO92 size package. The multiplexer portion is very small and requires approximately 300 logic gates.

2. References

- 2.1 Applicable Publications**—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

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

SAE J1850—Class B Data Communications Network

U. Kiencke, S. Dais, and M. Litschel, "Automotive Serial Controller Area Network," SAE Technical Paper Series, International Congress and Exposition, February 1986

D. J. Arnett, "A High Performance Solution for In-House Networking - Controller Area Network (CAN)," SAE Technical Paper Series, Earth-Moving Industry Conference, April 1987

T. Wroblewski, "A CSC Bus Multiplexing Technique Which Allows for Common Electronic Modules," SAE Paper 89123, 20th ISATA, Florence, Italy; May 1989

- 2.1.2 OTHER PUBLICATIONS

R. Vig and T. Wroblewski, "Addressable Single Wire Magnetic Sensor IC for Multiplexed Control," 3rd International Conference "Automobile Electronics - Interface and Environment," SIA. Toulouse, France; April 1988

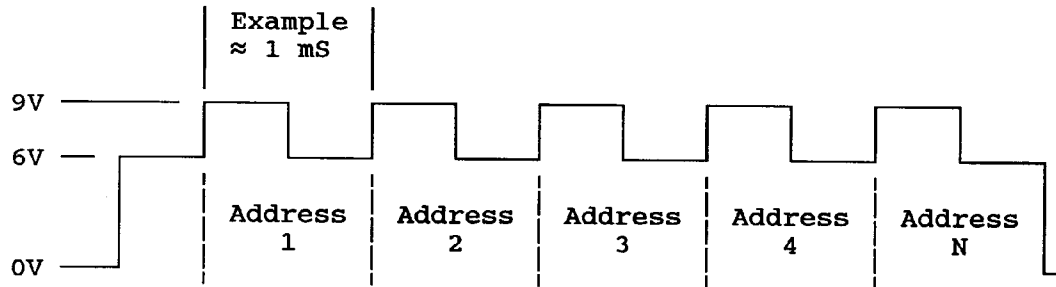
T. Wroblewski, "A Multiplexed Automotive Sensor System," Sensors, February 1989

- 3. Proposed Protocol**—The network method for this communication system is a master-slave polling and/or direct address method. The master uses a voltage waveform to communicate to the sensors and actuators. A sensor is addressed through successive, ordered polling of each address (time slot or period) in ascending order.

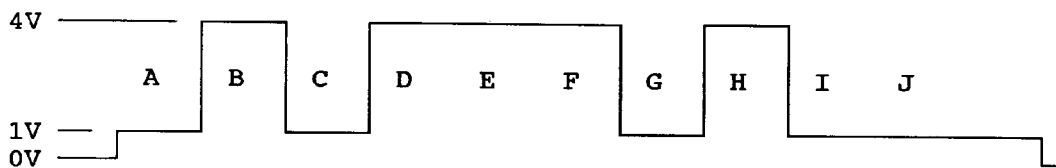
<SOM>, Wake-Up Period, Addr 1, Addr 2, ..., Addr 32

An actuator may be controlled by either the polling mode above or the direct-address, command-mode message below. The 'start of message' (SOM) is defined as the rising edge from 0 V to 6 V in the voltage waveform of Figure 1a.

<SOM>, <Five-Bit address>, <1 to N data bits>, {<parity bit>}



a. CSC Bus Sensor Polling Mode Voltage Waveform



b. Voltage Representing Current Drawn by the CSC Sensors

A: Sensor Power Current	B: Sensor Presence Current
C: Switch Open	D: Sensor Presence Current
E: Switch Closed	F: Sensor Presence Current
G: Switch Open	H: Sensor Presence Current
I: Switch Open	J: No Sensor Present

FIGURE 1—CSC BUS SENSOR POLLING MODE WAVEFORM

3.1 Continuous Polling Mode Sensor Multiplexing—Sensor multiplexing was addressed first because sensors outnumber actuators in the vehicle. Figure 1 contains the typical voltage waveform used to communicate with multiplexed sensors. As shown, the sensors use current to respond back to the master which generates the voltage waveform. In this scheme, each sensor has an internal preprogrammed address. The voltage begins at a reset (0 V) level and climbs to 6 V. This initial 6 V level provides power to the sensors. During this time, the master reads the amount of current required to keep the sensors powered, called the sensor power current. At each change from 6 to 9 V, a counter contained in the sensor is incremented. The sensors are addressed consecutively so this mode of CSC Bus communication is called the 'Continuous Polling Mode'.

4. CSC Bus Sensor Component Description—Two CSC components are available as of this publication;

- a. CSC Bus Two-Pin Hall-Effect Sensor
- b. Driver/Receiver Master Interface

4.1 CSC Bus Hall-Effect Sensor—(Reference Allegro P/N A3054U)

While the voltage is at approximately 9 V, the sensors compare the value in their counter to their preprogrammed address. If a sensor detects a match between these two values, the sensor will increase the current drain on the CSC Bus. This 'response current' informs the master that a sensor has recognized its address. This condition remains until the voltage falls to about 6 V.

When the sensor being addressed detects that the voltage is below its threshold of about 7.5 V, it will determine the status of the sensing element (magnetic field detecting Hall effect sensor, optical sensor, or mechanical switch to ground). If the sensing element is active (a magnetic field is detected, light is detected, or a mechanical switch to ground is closed), the sensor continues to draw the response current so that the master can sense the sensor's status. If the sensing element is not active, response current will cease and only the sensor power current will be drawn.

Each sensor is addressed in this manner until sensor address 32 has been addressed. After address 32, the voltage waveform returns to reset. The following blocks shown in Figure 2 are required to implement the CSC Bus Hall-Effect Sensor:

- a. Clock and Level Detector
- b. Five-Bit Address Counter
- c. Address Detector
- d. On-Chip Power Supply
- e. Constant Current Sink
- f. Sensing Element

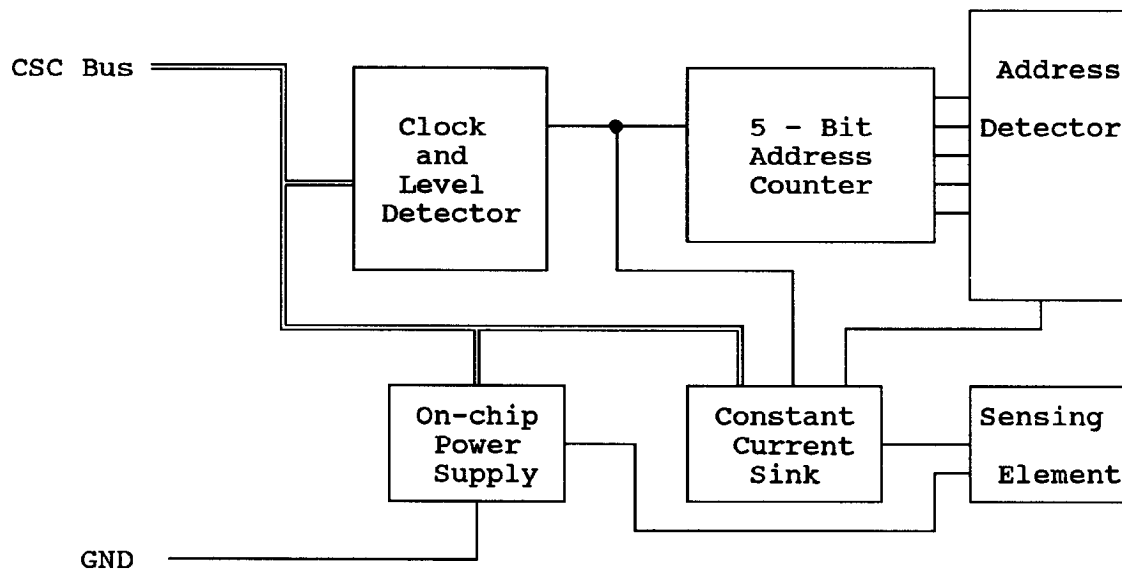


FIGURE 2—CSC BUS SENSOR BLOCK DIAGRAM

- 4.1.1 **CLOCK AND LEVEL DETECTOR**—The Clock and Level Detector block contains a comparator which detects the voltage level on the CSC Bus. When the voltage rises to approximately 8 V, the comparator output becomes high and a positive signal increments the 5-Bit Address Counter. This signal is also used in the logic to enable the Constant Current Sink. Due to the comparator's 1 V hysteresis, the comparator waits until the voltage falls to about 7 V before its level returns low. The 1 V hysteresis prevents incorrect changes in the output of the comparator when low level oscillations are coupled to the CSC Bus line.
- 4.1.2 **5-BIT ADDRESS COUNTER**—The 5-Bit Address Counter monitors the address period being queried by the master. The Clock and Level Detector provides the signal which increments the counter. This counter resets each time the CSC Bus returns to the reset level (approximately 0 V).