

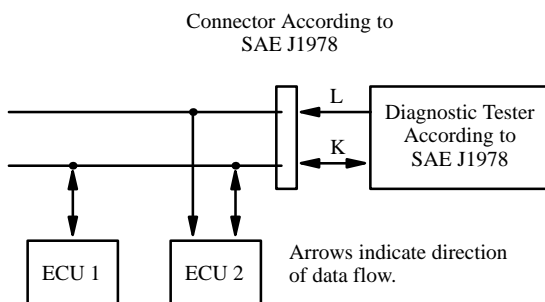
# Driver ICs for Automotive Diagnostic Communications Meet ISO 9141 Standards

by John Bendel

A series of compact, single-ended bus drivers for automotive diagnostic applications enables communication over the relatively long distances between testing equipment and automotive electronic control units, while protecting sensitive logic devices from the hazards of the automotive environment. The Si9241EY and Si9243EY are the first narrow-body, small outline products on the market to meet the ISO 9141 standard for this application.

## ISO 9141 (General Description)

ISO 9141 is an international standard for communications between automobiles and diagnostic testers. It specifies a serial data communication bus between the vehicle's Electronic Control Units (ECUs) and the diagnostic test SAE OBDII Scan Tool (SAE J 1978). ISO 9141 has been adopted by the California Air Resources Board for all cars sold in California with feedback fuel control systems. Similar rules are being adopted in New York, New Jersey, Massachusetts, and Maryland, and are expected to affect the design of most cars sold in the United States.



**Figure 1.** Possible System Configuration

Figure 1 is a system configuration for the ISO 9141 specification. The primary form of communication is with the single ended K-Line. The K-Line passes data bidirectionally, as well as transferring all address information during initialization.

The optional L-Line is unidirectional, and is only used to pass address information from the diagnostic tester to the ECUs during initialization. The L-Line is in a 1 state during all other events. The K-Line will mimic the L-Line's address initialization.

## Siliconix ISO 9141 Drivers

Siliconix has produced two drivers to meet ISO 9141 configurations. Each driver is housed in a small-outline surface mount package with on-board fault protection to protect the controller and tester from the automotive environment.

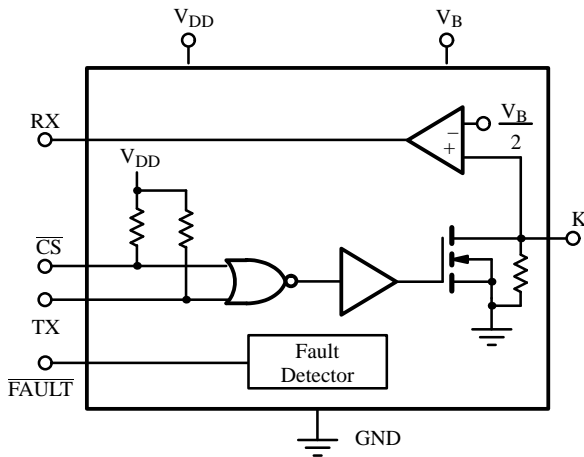
Both drivers have short circuit and over-temperature protection and open load detection. The devices protect against voltage transients ( $-3 V^3 [V_{bat}, K \text{ and } L] \leq 45 V$ ), which exceed ISO 9141 (-1 V to 40 V).

### The Drivers

The Si9241EY (Figure 2) is designed for the user that needs only K-Line communication. The ECU controls the K output through Transmit Pin (Tx) and Chip Select Bar ( $\overline{CS}$ ). The fault detection circuitry monitors Tx and K to determine open and shorted loads. If K is high when Tx is low, the K-Line is shorted. Conversely, if K is low when Tx is High, the K-Line is open. Over-temperature protection is always enabled, so a fault is determined whenever the junction temperature exceeds 150°C. All faults are latched until chip select bar is set "high."

If chip select is not to be used, TX and  $\overline{CS}$  Bar should be tied together, so all faults will reset when Tx toggles high.

The Si9243EY (Figure 3) is designed for users that need both K and L Lines for communication. It is packaged in an SO-8 for space savings, but due to pin limitation, it does not have a chip select function. For the same reason, the Fault Detection signal is not bonded out. The fault detection and protection circuitry are active, and the device will shut down in the event of a fault.



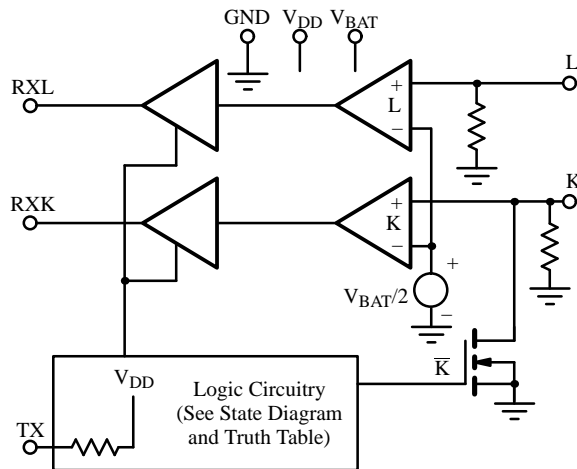
**Figure 2.** Si9241 K-Line Only Driver

Since the fault detection signal is not brought out, it is up to the user to determine if a fault has occurred. One method is to monitor the RxK and TX lines and ensure they are in phase. An exclusive OR can also perform the fault function.

The fault condition is cleared when TX is set high.

### System Anomalies

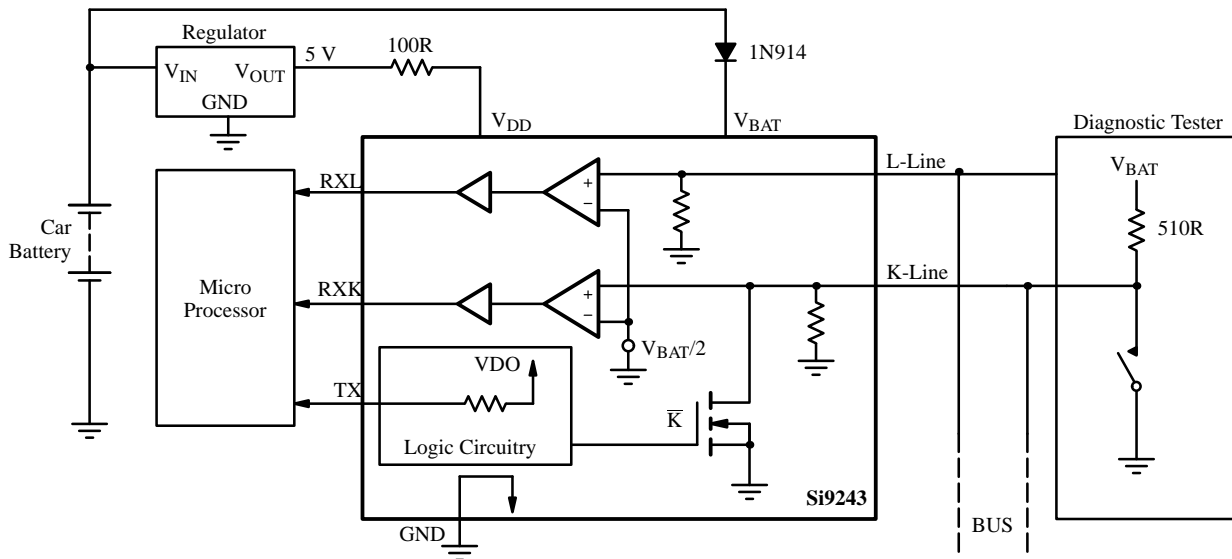
Two system anomalies in the automotive environment that the Si924x drivers may be subjected to are Reverse Battery and Ground Disconnect.



**Figure 3.** Si9243 K- and L-Line Driver

The Si924x drivers have an integrated diode in the  $V_{BAT}$  line to protect the device from reverse battery conditions. This diode will protect the IC to reverse batteries up to  $-18\text{ V}$ .

It is more difficult to protect the device against a ground disconnect. If the ground of an Si924x driver is disconnected and allowed to float, it is possible for the  $V_{DD}$  protection diode to forward conduct into the  $V_{BAT}$  line. A  $100\text{-}\Omega$  series resistor in the  $V_{DD}$  line will limit the current and prevent the device from failing as shown in Figure 4.



**Figure 4.** Si9243EY Applications Circuit

A second potential failure during ground disconnects is if the K-Line goes 8 V above the Bat line, while  $V_{DD}$  is still connected. Current will flow through the K-Line to  $V_{BAT}$  through a parasitic n-p-n. To remedy this situation, a diode must be placed in series with the  $V_{BAT}$  line (Figure 4). This condition will not occur if  $\overline{CS}$  and TX are low.

Logic "1"/Receiving	Logic "0"
K (ECU to GND)	$\geq 50 \text{ k}\Omega \leq 110 \text{ W}$
L (ECU to GND)	$\geq 50 \text{ k}\Omega \text{ N/A}$

Any resistance placed between the K or L Line and  $V_b$  must have a value greater than 100 k $\Omega$ .

## Signal and Communication Specifications

ISO 9141 specifies different logic levels for the Receiver and Transmitter.

### Receiver Logic Levels:

$$\text{Logic "0"} \leq 0.3 * V_{bat}$$

$$0.7 * V_{bat} \leq \text{Logic "1"}$$

### Transmitter Logic Levels:

$$\text{Logic "0"} \leq 0.2 * V_{bat} \leq 0.8 * V_{bat}$$

$$V_{bat} \geq \text{Logic "1"}$$

The Siliconix drivers operate to the above specifications, but with a slightly tighter transmission requirement: Logic "1" minimum  $\geq 0.91 * V_{bat}$ .

A logic bit transition must be less than 10 percent of the total bit time. The transition time is measured between the 80 and 20 percent battery points. Bit time is defined as the time between the 50 percent battery points of consecutive rising and falling levels.

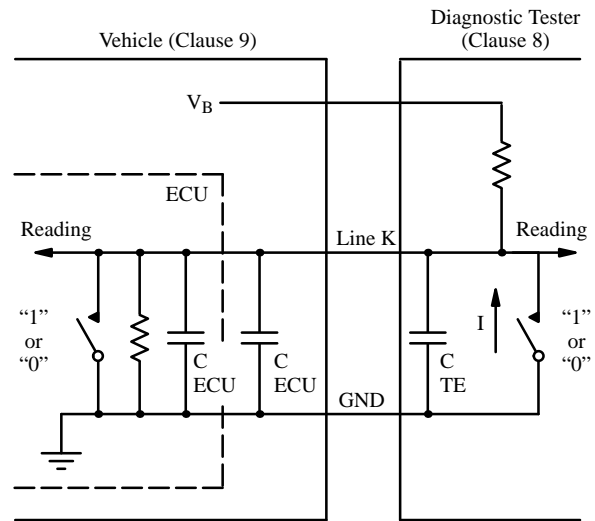


Figure 5. Communication Schematic

## Physical Layer

Figure 5 shows the physical layer capacitance of the ISO 9141 communication scheme.

$$C_{TE} = \text{Tester and Cables}$$

$$C_{OBW} = \text{On-Board Wiring}$$

$$C_{ECU} = \text{Sum of all ECU Input Capacitance}$$

where  $C_{ECU} + C_{OBW}$  is less or equal to 7.6 nF and  $C_{TE}$  is less or equal to 2 nF.

The capacitance of the K or L Lines with respect to GND can be no greater than 500 pF.

The resistance of the K and L Line is specified with respect to their State.

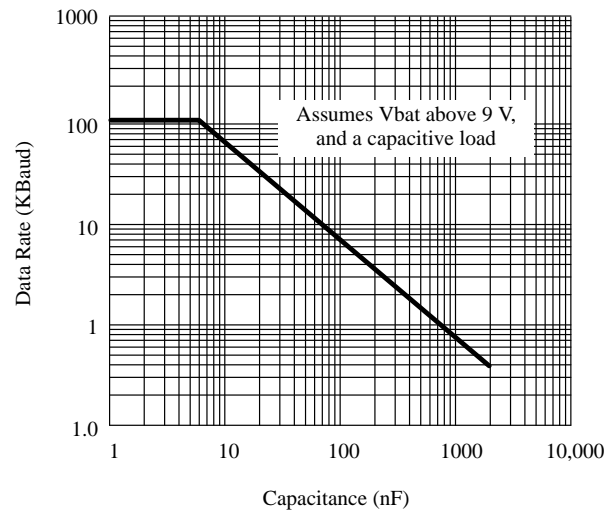


Figure 6. Maximum NRZ Data Rate with Capacitive Load Si924X with 510  $\Omega$  Load

## Data Rate

The maximum data rate will vary depending on the number of ECUs and length of cabling. ISO 9141 specifies a maximum bus capacitance of 9.6 nF. Figure 6 shows the maximum data rate versus capacitance.

## Data Format and Protocol

This application note will only give a general outline of the ISO 9141 communication scheme. The user is advised to read the actual ISO 9141 specification.

### *Initialization*

Before initialization, the K-Line is a Logic 1 for the time period of the address to be transmitted. The diagnostic tester then sends an 8-bit address on the K and L lines (one start, 8-bit address, one stop) to the ECU.

### *Transmission*

Before transmitting, the K-Line is a Logic 1 for the time period of the word to be transmitted. An alternate bit pattern is then sent to synchronize the receiver and set the baud rate. After the transmission of the synchronization

pattern, two key words are sent to the tester to identify the form of the data and the hardware configuration.

When the last key word is sent by the ECU, the tester will echo back the logic inversion of the last word back to the ECU. When this is complete, the ECU will transmit the logic inversion of the initialization address.

## Conclusion

Siliconix' ISO 9141 bus driver series is produced to save the automotive designer time and space while improving the overall reliability of the diagnostic system. Each driver exceeds the ISO 9141 transient and data requirements, as well saving significant space overall to a discrete solution. With these factors considered, it should reduce manufacturing, building and design costs, and produce a very economical solution to automotive bus interfacing.

## Reference

ISO 9141 - CARB Road Vehicles – Diagnostic Systems. N425/rev. Jan. 91