CAN OBD READER REFERENCE DESIGN KIT USER GUIDE

1. Standard ToolStick Handling Recommendations

The ToolStick Base Adapter and daughter cards are distributed without any protective plastics. To prevent damage to the devices or the host PC, please take into consideration the following recommendations when using the ToolStick:

- Never connect or disconnect a daughter card to or from the ToolStick Base Adapter while the Base Adapter is connected to a PC.
- Always connect and disconnect the ToolStick Base Adapter from the PC by holding the edges of the board.

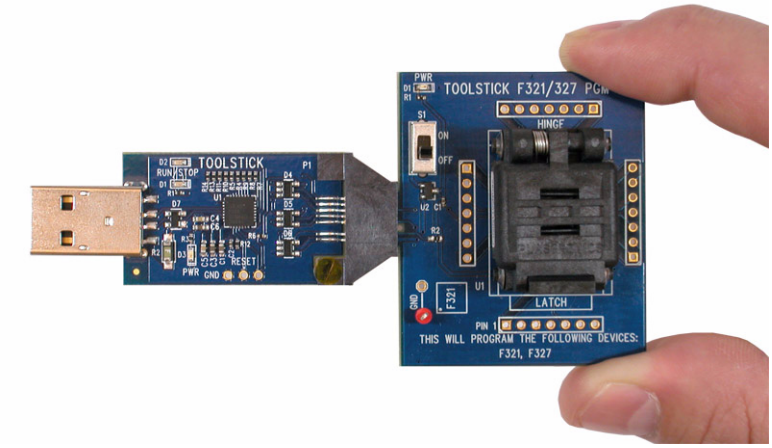


Figure 1. Proper Method of Holding the ToolStick

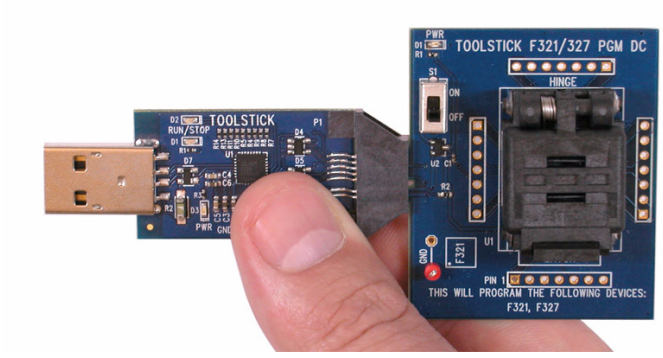


Figure 2. Improper Method of Holding the ToolStick

- Avoid directly touching any of the components other than the plastic connector or the socket.

2. Kit Contents

- ToolStick Base Adapter
- CAN OBD ToolStick Daughter Card using C8051F502 MCU
- 3-foot USB extension cable
- 3-foot OBD-II cable
- Silicon Labs Reference Design CD. CD content includes the following
  - ToolStick Terminal software
  - CAN OBD Reference Design firmware source code
  - CAN OBD Reference Design Kit User's Guide (this document)

3. Introduction

On-Board Diagnostics (OBD) is a protocol supported by current vehicles to capture and report diagnostic data. The Silicon Labs CAN OBD Reader Reference Design interfaces to the OBD-II port in a vehicle to retrieve the diagnostic error codes and status information. The retrieved information can be displayed on a Windows PC using the ToolStick Terminal software application. The reference design firmware can also decode a small subset of status information before displaying the results on the PC.

The OBD Reader supports modes 1, 2, and 3 of the OBD-II standard SAE J1979. These modes allow the OBD Reader to access the current data, show freeze frame data, and show the stored diagnostic trouble codes.

The purpose of the reference design is to demonstrate an automotive Silicon Labs microcontroller (MCU) interfacing to a vehicle with a very simple and straightforward design. The MCU communicates with the vehicle using the CAN (Controller Area Network) bus at 500 kbps and does not require an external crystal. Please note that the reference design is not intended to be a fully comprehensive OBD Reader.

Figure 3. CAN OBD Reference Design Hardware

4. Getting Started

This section details the necessary steps before the OBD Reader can be connected to a vehicle. First, the Windows software must be installed. Second, the hardware must be setup. The MCU's Flash comes preloaded with the firmware necessary for the OBD Reader.

4.1. Installing the Windows Software

The reference design kit includes a printed Quick Start guide that details how to install the software. The following software is installed from the CD:

- ToolStick Terminal
- Silicon Labs Integrated Development Environment (IDE)
- Keil C51 Toolset (evaluation version)
- OBD Reader hex file and source code

The default location for the ToolStick Terminal, CAN OBD firmware, and kit documentation is: C:\Silabs\MCU\ToolStick.

The default location for the Silicon Labs IDE and Keil C51 Toolset is: C:\Silabs\MCU.

The ToolStick Terminal software is the only software application necessary to use the reference design. The other software is provided so that the reference design hardware can be used as a development platform.

The ToolStick Terminal provides the standard terminal interface to the target microcontroller's UART. However, instead of requiring the usual RS-232 and COM port connection, ToolStick Terminal uses the USB interface of the ToolStick Base Adapter to provide the same functionality.

4.2. Setting Up the Hardware

The three main hardware components provided with the kit are the ToolStick Base Adapter, ToolStick OBD Reader Daughter Card, and the OBD-II cable. An optional USB extension cable is also included.

First, connect the OBD-II cable to the 4-pin header as shown in Figure 4.

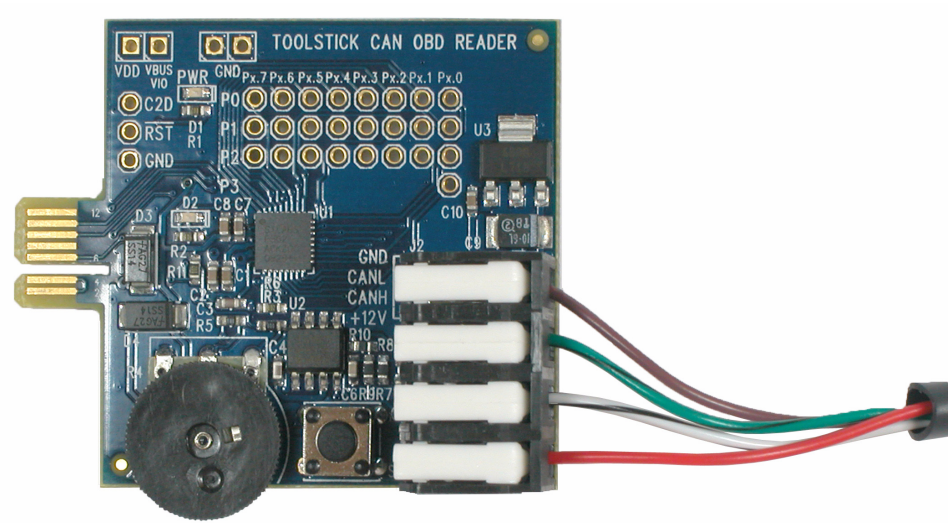


Figure 4. OBD Cable and ToolStick Daughter Card

Ensure that the proper wires are connected to the proper pins on the daughter card. Table 1 shows the functions of the four wires available on the OBD-II cable.

Table 1. OBD-II Cable

OBD-II Cable Wire Color	Function
Red	+12 V
White with black stripes	CAN_H
Green with black stripes	CAN_L
Brown	GND

Second, connect the ToolStick Base Adapter to the daughter card. Finally, connect the USB extension cable to the Base Adapter and connect the cable to a USB port on the PC.

Figure 5. OBD Reader Connected to the PC

5. Using the OBD Reader

Before the OBD Reader can be connected to the vehicle, the mode of operation and the power source must be selected. The options are described in more detail in Section 5.1 and Section 5.2.

5.1. Determining the Mode of Operation

The reference design has two modes of operation: real-time and stand-alone. In real-time mode, the user manually issues a request to the vehicle for a Parameter ID (PID) using ToolStick Terminal and the response is immediately reported. In stand-alone mode, the OBD Reader is preprogrammed with a list of PIDs to retrieve from the vehicle. The responses are stored in the MCU's Flash and can be retrieved later by the PC using the ToolStick Terminal application.

5.2. Power Options

The daughter card can be powered from the USB host through the ToolStick Base Adapter and it can also be powered through the CAN interface. The daughter card includes a 5 V regulator that can use the +12 V input from the vehicle.

If the reference design is used in real-time mode, the daughter card needs to be connected to the ToolStick Base Adapter to interface to the PC. In this configuration, the daughter card is powered from the USB host and the +12 V connection to the vehicle is not necessary.

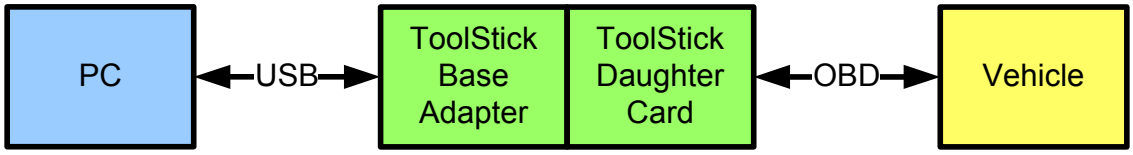


Figure 6. Real-Time Mode Operation

In stand-alone mode, the daughter card must be initially connected to the PC through the ToolStick Base Adapter to be programmed with list of PIDs to request. Once the daughter card is programmed, it can optionally be disconnected from the ToolStick Base Adapter as it can draw power directly from the vehicle.

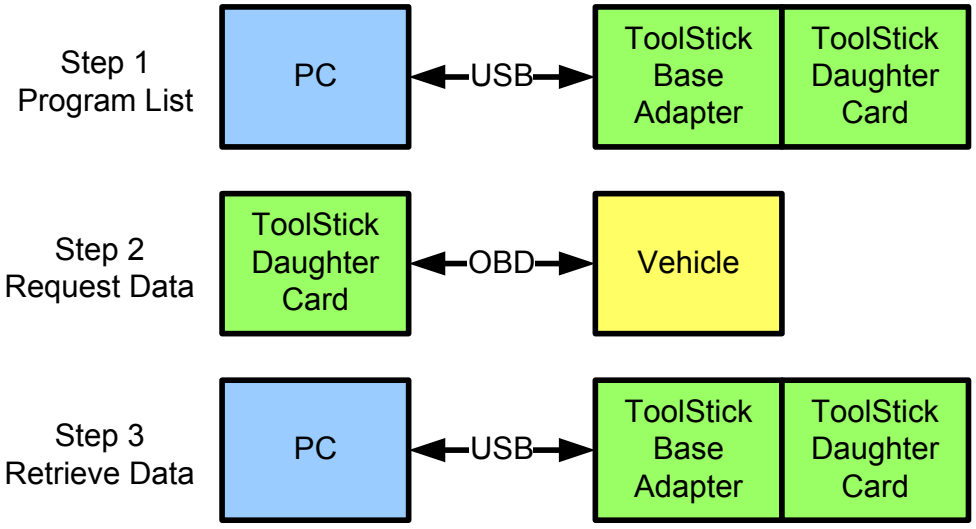


Figure 7. Stand-Alone Mode Operation

5.3. Connecting the OBD Reader to the vehicle

Once the mode of operation and power option have been determined, the OBD Reader can be connected to the OBD-II port in your vehicle.

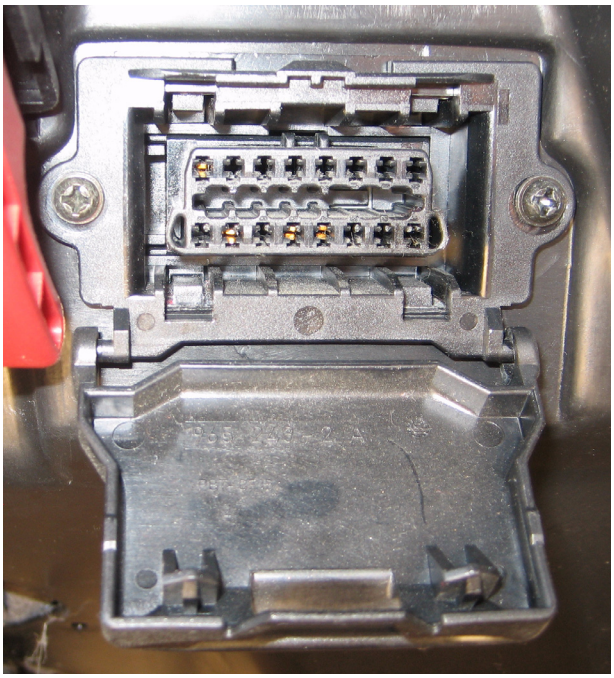


Figure 8. OBD Port

The interface to the OBD Reader is through the ToolStick Terminal application. The firmware running on the C8051F502 MCU uses the MCU's UART peripheral to communicate with the ToolStick Base Adapter. The firmware implements a command interpreter that accepts the commands listed in Table 2.

Table 2. OBD Reader Command Set

Command	Mode	Purpose
'I'	Both	List the PIDs supported by the reader
'M'	Both	Toggle between stand-alone and real-time modes
'O'	Real-time	Send a manual OBD request
'P'	Stand-alone	Start programming list of OBD commands
'R'	Stand-alone	Read results of OBD commands
'S'	Stand-alone	Stop programming OBD commands
Note: The command is not case sensitive.		

See Section 5.3.1 for instructions on using the device in real-time mode, and Section 5.3.2 for instructions for stand-alone mode.

5.3.1. Using the OBD Reader in Real-Time Mode

In real-time mode, the user can issue PID requests to the vehicle using ToolStick Terminal and receive the responses instantly. When the OBD Reader is in real-time mode, the green LED on the ToolStick daughter card will remain off.

Follow the steps below to configure the OBD Reader and issue PID requests.

1. Connect the OBD-II cable to the OBD port and turn on the vehicle. The OBD Reader should also be connected to the PC through the USB connection at this time.

Figure 9. Real-Time Mode Hardware Setup

2. Open the ToolStick Terminal application from the Start menu. The default location is Start Menu → All Programs → Silicon Laboratories → ToolStick Terminal.
3. The ToolStick Terminal application needs to be configured to communicate with the firmware interface on the MCU. In the application, go to ToolStick → Settings and select the following options:

Table 3. ToolStick Terminal Settings

Baud Rate	115200
Parity	None
Flow Control	None
Data Bits	8
Stop Bits	1

Click OK to save the settings.

4. The OBD Reader will appear in the Connection drop-down list in ToolStick Terminal. Click Connect. The OBD Reader will print a menu to ToolStick Terminal.
5. The relevant command in real-time mode is 'O'. The 'O' command issues a request for a PID. In the ToolStick Terminal Transfer Data window, type the following command and click Send Data.

Figure 10. Sending the OBD Request

The format for this command is as follows:

O - send an OBD request
02 - command length as required by the OBD protocol
01 - SAE J1979 mode (01, 02, or 03)
5C - PID requested in hex format
; - end of the command

The request for PID 0x5C in mode 1 will return the engine oil temperature. PID 0x5C is one of the supported PIDs and thus the firmware will interpret the data before printing it to the ToolStick Terminal. If a selected PID is not recognized, the firmware will print the raw data returned from the vehicle. The full list of PIDs recognized by the firmware is provided in "Appendix A - List of Supported PIDs" on page 14.

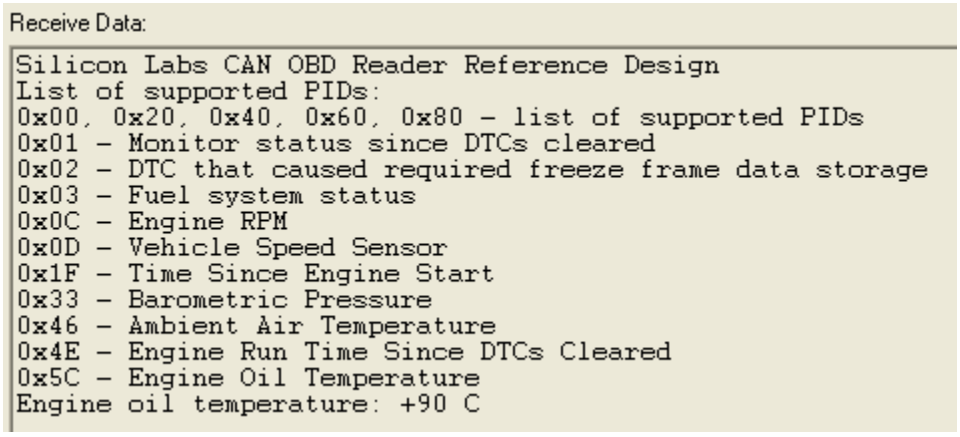


Figure 11. Response to the OBD Request

The list of supported PIDs will vary from vehicle to vehicle. The PIDs supported by this OBD Reader were selected for wide compatibility. A request for any PID that is supported by your vehicle can be issued using the format described above.

To return the list of trouble codes that are active in your vehicle, use the command O0103.

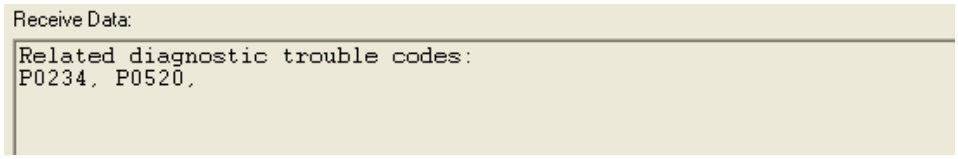


Figure 12. Sample Response to a Request for All Active Trouble Codes

There is no specific PID associated with the request for trouble codes. All active trouble codes will be returned with this command. The return codes can be looked up online on a website such as http://www.obd-codes.com to determine the specific problem. The OBD Reader does not include the ability to clear the trouble codes.

5.3.2. Using the OBD Reader in Stand-alone Mode

In stand-alone mode, the firmware on the MCU is programmed with a list of PIDs to request from the vehicle. Once connected, pressing the push-button switch on the daughter card triggers the firmware to serially issue all of the PIDs requests. The results are stored in the MCU's Flash. The daughter card can then be connected back to the PC to retrieve the responses.

5.3.2.1. Programming the MCU with the List of Requested PIDs

The first step to using the OBD Reader in stand-alone mode is to program the list of requested PIDs.

1. Open the ToolStick Terminal application from the Start menu. The default location is Start Menu → All Programs → Silicon Laboratories → ToolStick Terminal.
2. The ToolStick Terminal application needs to be configured to communicate with the firmware interface on the MCU. In the application, go to ToolStick → Settings and select the following options:

Table 4. ToolStick Terminal Settings

Baud Rate	115200
Parity	None
Flow Control	None
Data Bits	8
Stop Bits	1

   Click OK to save the settings.
3. The OBD Reader will appear in the Connection drop-down list in ToolStick Terminal. Click Connect. The OBD Reader will print a menu to ToolStick Terminal.
4. Type 'p' into the Transfer Data text window and click Send Data. This starts the programming mode. At this point, the firmware requests a file that contains a list of the PIDs to request.
5. In ToolStick Terminal, click on Send File. The reference design installation includes a text file with a list of selected PIDs. Browse for the file OBD_PID_List.txt that is installed by default to the C:\Silabs\MCU\ToolStick\CAN_OBD_DC directory.
   Click Open to send the file. The firmware will print "File has been written correctly" to confirm reception of the file.
6. Type 'm' into the Transfer Data text window and click Send Data. This will toggle the OBD Reader from real-time mode to stand-alone mode. The firmware will indicate that there are no stored results in the internal receive buffer.

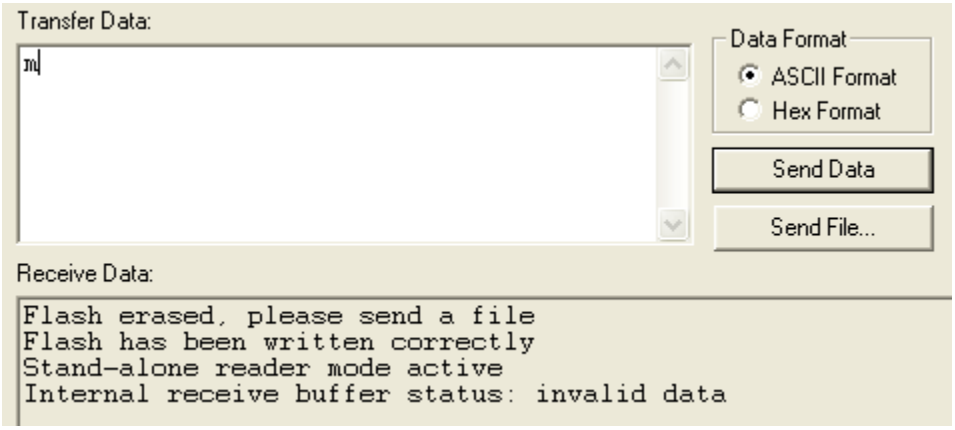


Figure 13. Receive Data Window after Steps 4 through 6

5.3.2.2. Issuing PID Requests to the Vehicle

Once the OBD Reader is programmed, it is ready to be connected to the vehicle. As covered in Section 5.2, the daughter card does not need to be connected to the ToolStick Base Adapter in stand-alone mode. The device can be directly powered from the vehicle.

1. [Optional] Disconnect the daughter card from the ToolStick Base Adapter. The daughter card and the OBD-II are the active components in the design.
2. Connect the OBD-II cable to the OBD port and turn on the vehicle. To verify that the device is in stand-alone mode, check that the green LED on the daughter card is turned on.

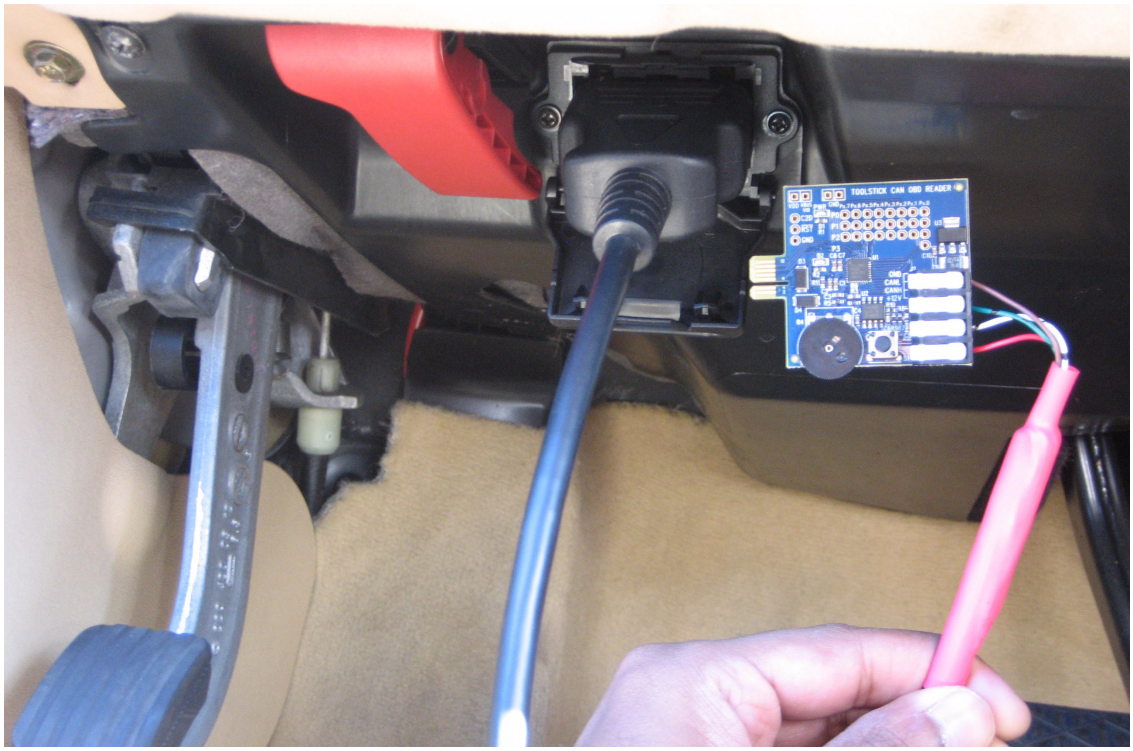


Figure 14. Stand-Alone Mode Hardware Setup

3. Once the daughter card is connected, press the push-button switch. This will request the data for the PIDs and store them to the MCU's Flash.

If the device is still connected to the ToolStick Terminal when the push-button is pressed, it will print the confirmation message "Device scan completed."

5.3.2.3. Reading the Results of PID Requests from the PC

Once the OBD Reader has acquired the data from the vehicle, it can be connected back to the PC to retrieve the data.

1. If the daughter card was disconnected when retrieving the PIDs, reconnect it to the ToolStick Base Adapter and reopen the connection in ToolStick Terminal. If the device was not disconnected, disconnect and reconnect from the device in ToolStick Terminal.
2. When the device is connected to ToolStick Terminal, it will print a message indicating that data in the receive buffer is active.
   Type 'm' in the Transfer Data field to put the device back into real-time mode.
3. Type 'r' in the Transfer Data field to print the retrieved results.

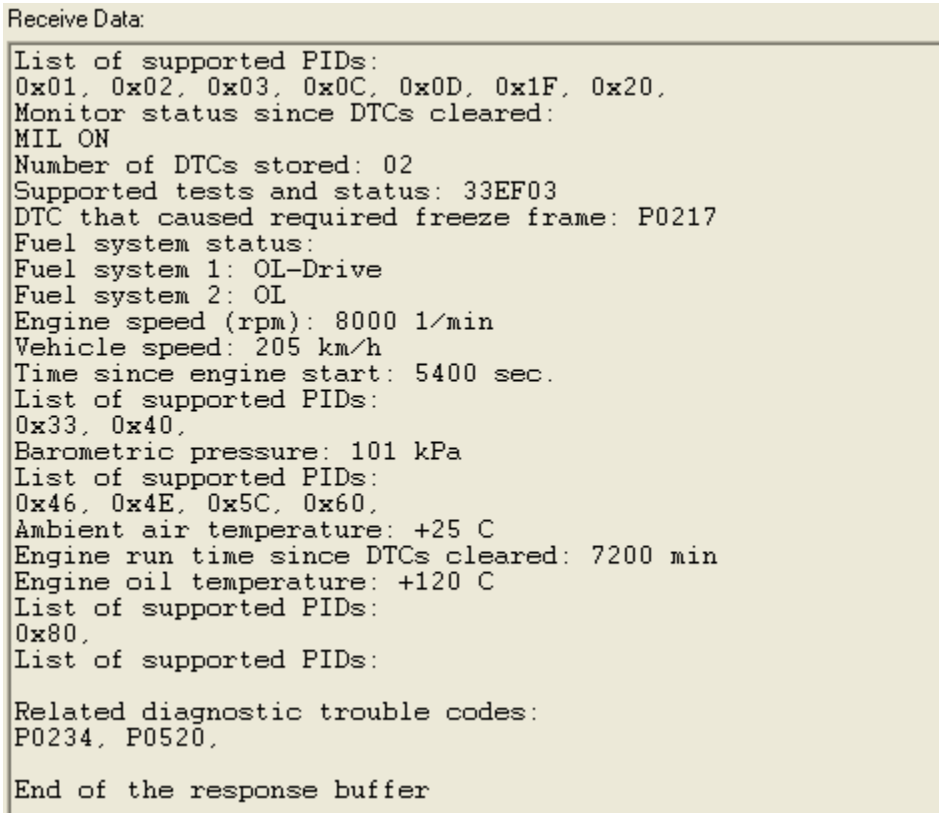


Figure 15. Sample Responses Acquired in Stand-alone Mode

6. Using the Reference Design as a Development Platform

The CAN OBD ToolStick Daughter Card also serves as a functionally complete development platform for the C8051F50x devices. This Daughter Card is very similar to the ToolStick C8051F502 Daughter Card, except that the CAN OBD daughter card includes a +5 V regulator for the +12 V supply from the vehicle.

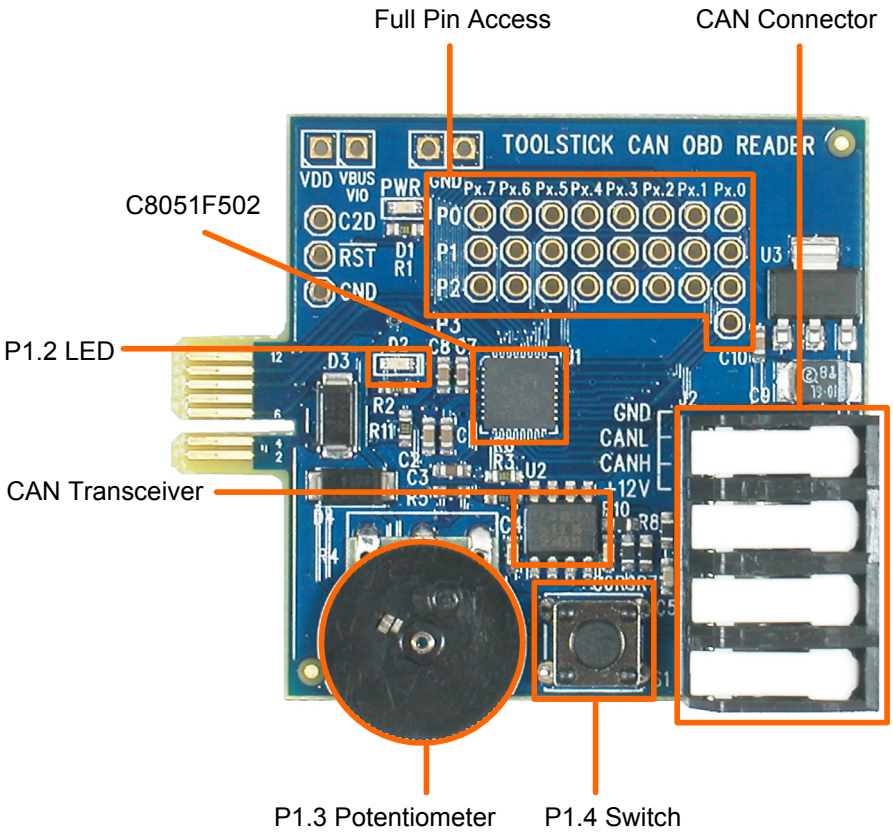


Figure 16. CAN OBD ToolStick Daughter Card Components

The instructional material and example firmware for the C8051F502 Daughter Card is directly applicable to the CAN OBD ToolStick Daughter Card. The User Guide and firmware examples for the 'F502 Daughter Card are part of the ToolStick Development Tools package which is available for download at www.silabs.com/toolstick.

7. Information Locations

The source code and the hex file for the CAN_OBD firmware is located at:

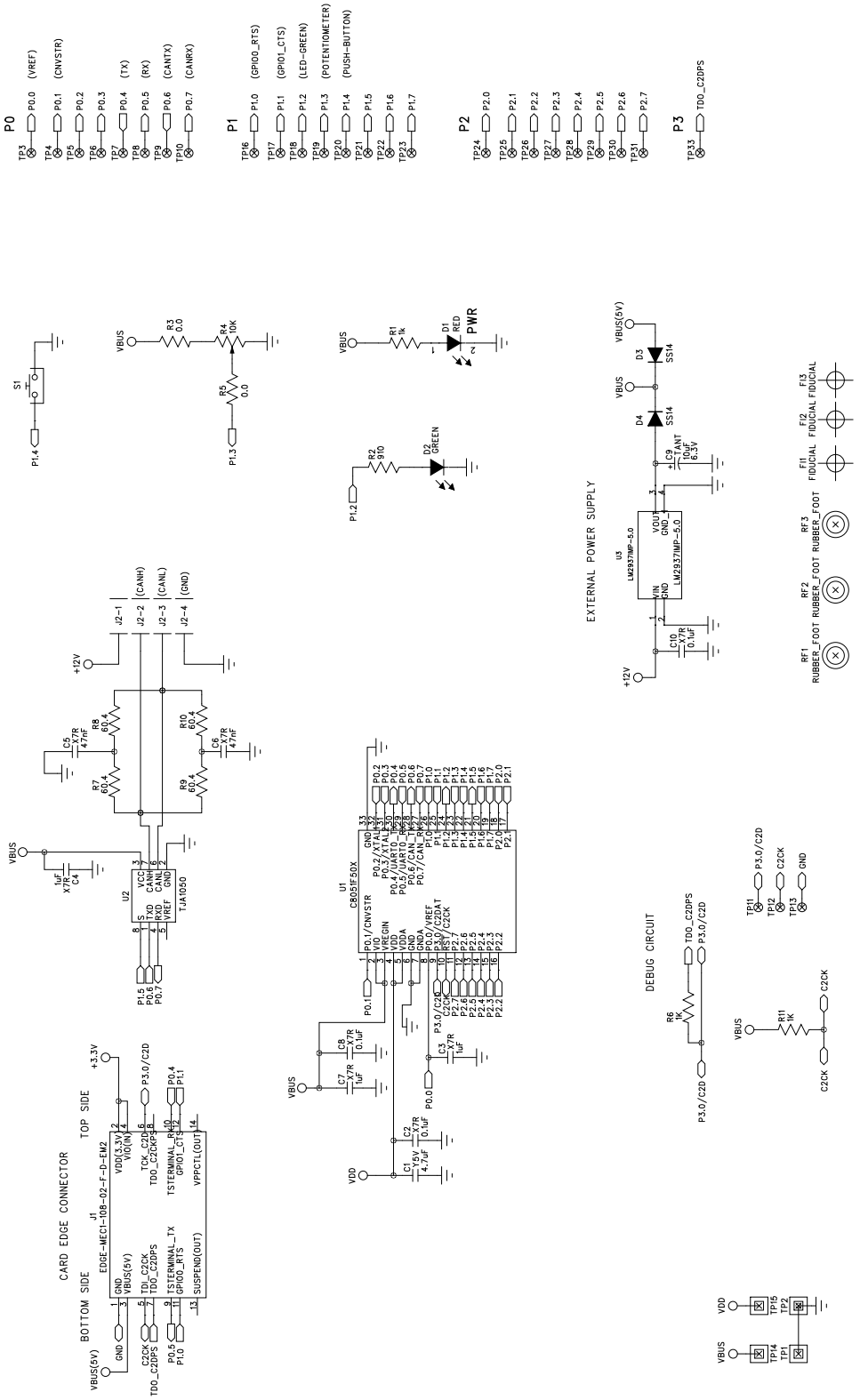
C:\Silabs\MCU\ToolStick\CAN_OBD_DC\Firmware

Documentation for the ToolStick kit, including this User Guide, can be found in the following two directories: C:\SiLabs\MCU\ToolStick\Documentation

C:\SiLabs\MCU\ToolStick\CAN_OBD_DC\Documentation

The installer for the ToolStick software is available at www.silabs.com/toolstick.

8. CAN OBD Reader Daughter Card Schematic



APPENDIX A - LIST OF SUPPORTED PIDS

The OBD-II protocol is specified in SAE J1979. This specification also includes definitions for standard PIDs.
The OBD Reader can interpret the data returned from a vehicle for the following PIDs:

- 0x00 - PIDs supported 0x01-0x1F
- 0x01 - Monitor status since DTCs cleared
- 0x02 - DTC that caused required freeze frame data storage
- 0x03 - Fuel system status
- 0x0C - Engine RPM
- 0x0D - Vehicle Speed Sensor
- 0x1F - Time Since Engine Start
- 0x20 - PIDs supported 0x21-0x3F
- 0x33 - Barometric Pressure
- 0x40 - PIDs supported 0x41-0x5F
- 0x46 - Ambient air temperature
- 0x4E - Engine run time since DTCs cleared
- 0x5C - Engine Oil Temperature
- 0x60 - PIDs supported 0x61-0x7F
- 0x80 - PIDs supported 0x81-0x88

If a requested PID is not recognized by the OBD Reader, the response is sent back to ToolStick Terminal as 16 bytes of ASCII encoded numbers with an "Unrecognized response:" prefix.

For example, if PID 0x41 was requested, the response sent to ToolStick Terminal would appear as:

"Unrecognized response: 0241028233FF63A7"

The OBD Reader is written to accept any message on the CAN bus. Any unexpected received responses are sent to ToolStick Terminal as 16 bytes of ASCII encoded numbers.

NOTES:

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