

Bowser Electronics RS232 to OBD Converter

OBD-121

GENERAL DESCRIPTION

The OBD-121 is a single chip computer used to provide frequency transition from RS-232 to the standard OBD protocols and back. Level shifting is accomplished through simple external circuitry. The OBD-121 provides no data manipulation, which affords the user maximum flexibility accessing the vehicle bus. All SAE J2178 message types are allowed as well as all ISO 15031-5 addresses. Several user configurable features allow customization from fully manual to fully automatic operation to make this device suitable for almost any application.

APPLICATIONS

- § SAE J1978 Compliant Scan Tools
- § Enhanced Mode J2190 Scan Tools
- § Performance Monitoring

USER CONFIGURABLE FEATURES

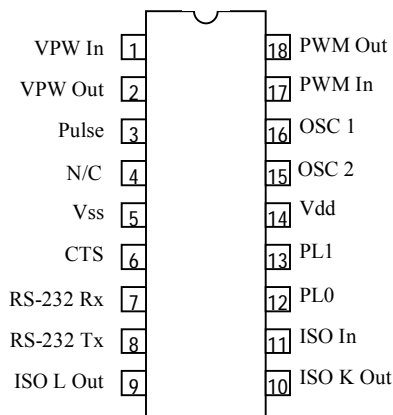
- § Automatic Protocol Selection
- § Automatic/User ISO Keep-Alive
- § CRC/Checksum Insertion
- § Connection Failure Diagnosis
- § Vehicle Bus Monitoring
- § Message Type Return
- § Number of Return Messages (256 max)
- § Tester Address / ISO Address

SYSTEM COMMUNICATIONS

On-Vehicle Communication Protocols

- § J1850 PWM
 - 41.6K baud (59 Frames/sec typ)*
 - Full line arbitration
 - Error detection (Bit error rate <0.1%)*
 - In Frame Response - Supported
- § J1850 VPW
 - 10.4K baud (38 Frames/sec typ)*
 - Full line arbitration
 - Error detection (Bit error rate <0.01%)*
 - In Frame Response – Not Supported
- § ISO-9141
 - 10.4K baud (9 Frames/sec typ)*
 - No line arbitration(Drop host<0.001%)*
 - Error detection (Bit error rate <1.0%)*
 - In Frame Response – Not Supported
- § ISO-14230 (KWP-2000)
 - 10.4K baud (9 Frames/sec typ)*
 - No line arbitration(Drop host<0.001%)*
 - Error detection (Bit error rate <1.0%)*
 - In Frame Response – Not Supported

Connection Diagram
Package Type:
300 mil PDIP



Off-Vehicle Communication Protocol

- § RS-232 Communication
 - 8 data bits
 - 1 stop bit
 - No parity
 - 57.6K baud
 - CTS – implemented

* Frame rates and error rates subject to limitations of PC and vehicle response times. Tested using 2GHz P4 PC and ECU-121 Bench test setup with typical bit timing.

HARDWARE CONNECTION

Example circuits are given later in this document for signal conditioning into and out of the various OBD-121 communication ports.

Pin 1 – VPW In – Non-inverted 0-5v input signal. This pin must echo back any data sent on VPW Out line. This input must be isolated from direct connection to the vehicle bus.

Pin 2 – VPW Out – Non-inverted 0-5v output signal. This output must be isolated from direct connection to the vehicle bus.

Pin 3 – Pulse – 0-5v output signal. This output toggles every 104ms to indicate normal processor function. During automatic protocol select, this output is idle.

Pin 4 – Not Used – Tie to +5v through a 10kohm resistor.

Pin 5 – Vss – System Ground.

Pin 6 – CTS – Inverted 0-5v output signal. A 0 on this line indicates the system is ready to accept commands through the RS-232 port.

Pin 7 – RS-232 Out – Inverted 0-5v output signal. This output must be inverted to be understood by a computer.

Pin 8 – RS-232 In – Inverted 0-5v input signal. This input must be inverted to be understood.

Pin 9 – ISO L Out – Inverted 0-5v output signal. A 1 on this line indicates driving the L-line low. This output must be isolated from direct connection to the vehicle bus.

Pin 10 – ISO K Out – Inverted 0-5v output signal. A 1 on this line indicates driving the K-line low. This output must be isolated from direct connection to the vehicle bus.

Pin 11 – ISO In – Non-Inverted 0-5v input signal. This pin must echo back, inverted, any data sent on ISO K Out line. This input must be isolated from direct connection to the vehicle bus.

Pin 12, 13 – PL0, PL1 – 0-5v output signal. Protocol LEDs. These 2 signals are used to indicate the active protocol as follows:

PL1	PL0	Protocol
0	0	PWM
0	1	VPW
1	0	ISO-9141
1	1	ISO-14230

Pin 14 – Vdd – 5v System Power.

Pin 15, 16 – OSC1, OSC2 – System Clock. 20MHz crystal oscillator. For reliable operation use only Epson CA301 series crystal.

Pin 17 – PWM In – Non-Inverted 0-5v Input signal. This pin must echo back any data sent on PWM Out line. This input must be isolated from direct connection to the vehicle bus.

Pin 18 – PWM Out – Non-inverted 0-5v output signal. This output must be isolated from direct connection to the vehicle bus.

ELECTRICAL SPECIFICATIONS

The core of the OBD-121 is a Microchip PIC16F628A microcontroller. For more detailed specifications or further information, see the Microchip website at www.microchip.com.

Absolute Maximum Ratings†

Ambient temperature under bias.....	-40 to +125°C
Storage temperature	-65°C to +150°C
Voltage on V _{DD} with respect to V _{SS}	-0.3 to +6.5V
Voltage on all other pins with respect to V _{SS}	-0.3V to V _{DD} + 0.3V
Total power dissipation (1)	800 mW
Maximum current out of V _{SS} pin	300 mA
Maximum current into V _{DD} pin	250 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin.....	25 mA
Maximum current sunk by ALL I/O pins.....	200 mA
Maximum current sourced by ALL I/O pins.....	200 mA

Note 1: Power dissipation is calculated as follows: $P_{DIS} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

† NOTICE: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the normal operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Normal Operating Conditions

Symbol	Characteristic	Min	Typ	Max	Units
V _{DD}	Supply Voltage	4.5	-	5.5	V
SV _{DD}	V _{DD} Rate of Rise	0.05	-	-	V/ms
I _{DD}	Supply Current	-	4.0	7.0	mA
V _{IL}	Input Low Voltage	V _{SS}	-	0.8	V
V _{IH}	Input High Voltage	2.0	-	V _{DD}	V
V _{OL}	Output Low Voltage	-	-	0.6	V
V _{OH}	Output High Voltage	V _{DD} - 0.7	-	-	V
T _{PROP}	Feedback Propagation Delay	-	-	3.0	μS
T _a	Normal Operating Temp	0		70	°C

SYSTEM OPERATION

The OBD-121 functionality is broken into three parts: host communication, system commands, and vehicle communication. All data communicated is in the binary, not ASCII, format (To send a command, transmit Chr(&hFF), not “FF”). There is no use of the ASCII character set in this device. Throughout this section, all communication will be described in Hexadecimal values and use the notation 0xXX (i.e. 0x10 = Hex number 10, Decimal number 16).

HOST COMMUNICATION

The OBD-121 uses an internal Universal Asynchronous Receiver/Transmitter (UART) to provide standard RS-232 communication between the chip and host. Communication parameters are fixed to enable the chip to communicate with the host faster than the vehicle is communicating with the chip. The CTS line is used to indicate when the chip is ready to accept commands from the host. This is an active low (0) signal. Once a complete command is received, the CTS line will go high (1) while the command is executed. During this time, the chip will communicate response messages. When all messages are complete, the CTS line will return to the low (0) state. Used in this manner, the CTS signal serves the dual purpose of indicating ‘system busy’ as well as ‘command cycle complete’. The host system should use the following serial port settings for communication with the OBD-121. Slower system should increase the buffer size when using the ‘Monitor Vehicle Bus’ feature as data can accumulate quickly.

Baud Rate	57600
Data Bits	8
Stop Bits	1
Parity	N
Buffer Size	2048
Handshaking	Hardware

The first byte of any communication from the host describes for the OBD-121 what type and how much data will follow. A value of 0xFF indicates a system command. The byte is bit encoded to define three parameters.

Bit {7} defines type of messages Returned:

{0} = Screened Messages; Only Return Messages with first byte = Screen Byte
(Screen Byte may be changed via system command)

{1} = All Messages Returned

Bits {6:4} define number of messages to be returned from the vehicle as follows:

Bit			Return Messages
6	5	4	
0	0	0	Max Allowed
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Bits {3:0} define number of bytes to follow in user message
 (Do not include format byte. This number is how many bytes get sent onto the vehicle bus)

Bit				Return Messages
3	2	1	0	
0	0	0	0	Not Valid
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

Remaining bytes contain the message to forward onto the vehicle bus.

e.g. 26 68 6A F1 01 00 17

First byte specifies Return max of 2 screened reply messages.

Message to transmit contains 6 bytes. Bytes 2 - 7 define the message to transmit to the vehicle bus.

SYSTEM COMMANDS

The OBD-121 uses several system commands to customize the operation of the system. These commands may be issued anytime the CTS signal is low (0). All commands begin with 0xFF. Upon receiving the 0xFF, the system will wait up to 13ms to receive the rest of a valid command message then set the CTS signal high (1). Invalid commands respond with a single byte 0xFF. The commands are outlined below:

- 0x00 Firmware Version Number.** Two-byte response. First byte is the major version; second byte is the minor version.
- 0x01 Currently enabled protocol.** Single byte response as defined below. During automatic protocol selection, this value may be invalid. Use command 0x08 to check initialization status.
- 0x00 None
 - 0x01 PWM
 - 0x02 VPW
 - 0x04 ISO-9141
 - 0x08 ISO-14230
- 0x02 Initialization response:** Depends on protocol. The response message is a fixed length of 10 Bytes. Unused bytes are set to 0x00. In manual mode, only the ISO protocols will store a response message.
- PWM Vehicle Response to Standard J1979 Mode \$01, PID \$00 request
 - VPW Vehicle Response to Standard J1979 Mode \$01, PID \$00 request
 - ISO9141 Messages communicated during bus initialization as follows:
 - Byte 1: Service Address (defaults to 0x33)
 - Byte 2: Speed Syncro Byte (always 0x55)
 - Byte 3: Average Bit Time (Bit Time(μS) = (Byte 3 * 1.6))
 - Byte 4: Key Byte 1 (0x08 or 0x94)
 - Byte 5: Key Byte 2 (0x08 or 0x94) (Same as Key Byte 1)
 - Byte 6: Inverse of Key Byte 2 (0xF7 or 0x6B)
 - Byte 7: Inverse of Service Address (defaults to 0xCC)
 - ISO14230 Vehicle Response to the Start Communication Service
- 0x03 Reset System!** Single byte reply 0x03. Clears all memory and restarts system. System waits 1 second for PWM and VPW protocols and 6 seconds for ISO-9141 and ISO-14230.
- 0x04 Start Continuous Receive.** Single byte reply 0x04. Causes system to constantly receive any messages being transmitted on the bus and retransmit them on to the RS-232 Line.
- 0x05 Stop Continuous Receive.** Single byte reply 0x05. Stops a previously issued 0x04 command and returns system to normal operation.
- 0x06 Manual Protocol Select.** 1 Value byte required. Valid values follow. If more than one bit is set, the system will use the LSB as the protocol (i.e. sending value of 0x05 will enable PWM). One return byte indicates protocol selected.
- 0x00 None
 - 0x01 PWM
 - 0x02 VPW
 - 0x04 ISO-9141
 - 0x08 ISO-14230
- 0x07 ISO Initialize.** Send ISO Initialization Sequence. Returns standard return values to indicate success or failure. 0xFF indicates ISO protocol was not selected when initialize command issued.
- 0x08 Check Online Status.** Single byte response used to indicate initialization status as follows. Note: PWM and VPW, when selected in manual mode, will by default indicate initialized.
- Bit 6 = 1 System initialized and ready for vehicle communication.
 - Bit 7 = 1 System initialized for ISO and ready for vehicle communication.

- 0x10 Set ISO Target Service Address.** 1 Value byte required. Default is J1979 Service address 0x33.
- 0x11 Set Scantool Address.** 1 Value byte required. Default is J1979 Scantool address 0xF1.
- 0x12 Set Maximum Message Length.** 1 Value byte required. Valid Message Lengths are 0x00 – 0x0F. Default is J1979 Max Length 0x0C.
- 0x13 Set Maximum Number of Reply Messages.** 1 Value byte required. Valid Range is 0x01 – 0xFF. Default is 0x20.
- 0x14 Set RS232 Delay.** 1 Value byte required. Sets minimum time to hold CTS Low. $\text{Time}(\mu\text{S}) = \text{RS232Delay} * 409.6$ Default Value = 0x0A (4096 μS) Some older PCs may need to increase this time if the PC is missing the CTS transitions.
- 0x15 Set Startup Option Flags.** 1 Value byte required.
 Bit 0 = 1 Enable extended codes to be sent during startup
 Bit 1 = 1 Enable Automatic CRC/Checksum Insertion
 Bit 2 = 1 Disable Automatic Protocol Select
 Bit 3 = 1 Disable Automatic Keep Alive
 Bit 4 = 1 Enable User Keep Alive Message
 Default Value = 0x00
- 0x16 OBD Message Separator.** 1 Value byte required. Byte System will transmit between vehicle response messages. Default is '0xFF'.
- 0x17 Second OBD Message Separator.** 1 Value byte required. Determines if two separator bytes are transmitted between vehicle response messages. Default is '0x0C' (two byte replies from both ISO formats).
 Bit 0 = 1 Enable Second Separator Byte on PWM
 Bit 1 = 1 Enable Second Separator Byte on VPW
 Bit 2 = 1 Enable Second Separator Byte on ISO-9141
 Bit 3 = 1 Enable Second Separator Byte on ISO-14230
- 0x18 ISO9141 BUS IDLE TIME.** 1 Value byte required. Sets time to wait in mSec before transmitting ISO address byte during initialization. Default value = 0x3C (~6 Seconds)
- 0x20 Reset Commands 0x10 – 0x1F to Default Values.** Single byte reply 0xF0.
- 0x21 Read Command Value.** 2 Value bytes required. Byte 1 is command number to return value from. Valid Range 0x10 – 0x2F. Byte 2 is where to retrieve data from. Byte 2 = 0x00 returns data from RAM, Byte 2 = 0x01 returns data from EEPROM. Returns 1 byte value indicating current command value.
- 0x22 Set Screened Response Byte.** 1 Value byte required. This is the first byte of the vehicle response message. All messages that start with this byte will be passed through to the RS-232 bus when the 'Screened Only' message type is specified in the vehicle command. This value is not saved in EEPROM memory and must be set each time it is used. Initially set at protocol selection = 0x41 for PWM, 0x48 for VPW, NOT USED for ISO.
- 0x30 User Keep Alive Message.** 1 Value byte required, up to 10 bytes allowed. Start data with length of message byte. Checksum automatically appended to message before transmit (e.g. '05686AF10100', '05' length of message, '686AF10100' message, Checksum will be appended). When using command 0x21 to read values, they are stored only in the EEPROM starting with the length byte at location 0x20.

VEHICLE COMMUNICATION

Vehicle sourced messages will be retransmitted byte by byte as they are received. The OBD-121 inserts end of message bytes, as specified by command 0x16 and 0x17, at the end of each vehicle message. When all messages are received, a one-byte error code is transmitted followed by any In Frame Responses received during transmission.

ERROR CODES

Any time the host makes a request the OBD-121 sends a response code to indicate the state of completion. Response codes for System Commands are indicated in the description for each command. Vehicle requests use the following response codes.

OBD-121 Response Codes

Response	Description
0x00	No Errors
0x01	Start Receive Timeout
0x02	SOF High Max Time Exceeded
0x03	SOF High Min Time Not Exceeded
0x04	SOF Max Bit Time Exceeded
0x05	SOF Min Bit Time Not Exceeded
0x06	Data High Max Time Exceeded
0x07	Data High Min Time Not Exceeded
0x08	Data Bit Len Min Not Exceeded
0x09	Too many Bytes Received
0x0A	Last Byte Does Not Contain 8 Bits
0x0C	Min EOF Time not exceeded before SOF
0x0E	ISO NO STOP BIT AT END OF BYTE
0x14	ISO KEYWORD RECEIVE ERROR
0x16	ISO KEYWORD 2 TRANSMIT ERROR

Response	Description
0x17	ISO ADDRESS RECEIVE ERROR
0x18	ISO WRONG ADDRESS RECEIVED
0x20	RS-232 Byte Receive Timeout
0x21	Invalid Control Byte
0x22	Invalid Message Length
0x23	Transmit Arbitration Timeout
0x24	Line Stuck High
0x25	Line Stuck Low or no feedback
0x26	Expected IFR with no response
0x27	IFR Data High Max Time Exceeded
0x28	IFR Data High Min Time Not Exceeded
0x29	IFR Data Bit Len Min Not Exceeded
0x2A	IFR Too many Bytes Received
0x2C	IFR Started before EOD min
0x2D	ISO Not Initialized before Transmit Call

APPLICATION EXAMPLES

Circuit and programming examples are available on the Bowser Electronics website.