# AN-001 OBD-121 / ECU-121 Practical Example Circuit

## GENERAL OVERVIEW

In this application note, we will present and discuss an example circuit to perform the level shifting necessary to interface the OBD-121 / ECU-121 to an external host computer as well as a vehicle using all three of the supported protocols. General system connection for signal, power, and oscillator will be discussed as well. Areas of concern for vehicle level shifting are appropriate voltage level matching and signal propagation delay from output to input.

## SIGNAL LEVELS

Table 1 shows minimum and maximum values for 0 and 1 data bits for each protocol. For each protocol the 'grey' signal level area may be interpreted as either a 0 or a 1. VPW and ISO use a 2.5v delimiter after scaling the input to 0-5v, PWM uses a straight differential signal, and RS-232 is generally 1.0v before scaling.

Table 1: Signal Levels

| Protocol | Signal Level | | | |
|---|---|---|---|---|
| | 0 | | 1 | |
| | Min | Max | Min | Max |
| RS-232 | 3 | 25.0 | -25.0 | -3 |
| PWM | 0 | 1.2 | 3.8 | 5.3 |
| VPW | 0 | 1.5 | 6.3 | 8.0 |
| ISO | 0 | 3.0 | 9.0 | 12.0 |

### RS-232 Signals

The OBD-121 / ECU-121 sends and receives data inverted from normal. This allows simple interface to both transistor and IC line driver/receivers. The RS-232 Section of figure 1 shows the implementation of a driver/receiver and figure 2 shows simple transistor level shifting. The transistor example takes advantage of the fact that most PC serial ports level transition at ~1v above ground. Negative signals should be clamped to ground to avoid damage to the transistor and chip.

### Vehicle Signals

Signal reception from the vehicle is accomplished through use of a simple comparator circuit. Where needed, a resistor divider network is implemented across the non-inverting input to reduce the maximum signal to 5v. PWM protocol is a differential 5v signal and can be connected directly to the comparator inputs through current limiting resistors. ISO and VPW require a 2.5v reference signal to be connected to the inverting input. This reference can be derived from the main supply through a simple resistor divider network. The use of a comparator on the input circuit provides buffering from the vehicle bus as well as a high impedance load.

Signal transmission is implemented through the use of drive transistors and load resistors to match vehicle bus load expectations. The signal is buffered such that idle bus conditions can be met during chip idle or chip not present conditions. The ISO bus is a normally high bus with 510 ohm path to $V_{BATT}$. The J1850 Bus is a normally low bus with the + rail pulled low and the – rail pulled high with a 2kohm path to Ground. Because the VPW and PWM protocol share the same + line with different high signal level requirements, both outputs are diode protected from each other.

## PROPAGATION DELAY

All vehicle signals are verified for proper signal level on transmission. When a signal is transitioned from passive to active or active to passive, the level transition is verified to determine both arbitration and bus stuck errors. The transition is verified after 3µs. Any circuit employed to interface to the vehicle must feed the output signal to the input signal within the 3µs limit. Typical comparator delays are <1µs. Drive transistor on/off times vary widely from <2µs to >10µs. Careful design of the vehicle transmission drive section is required. The OBD-

121 / ECU-121 verifies both on and off transition times. The transistor on time is generally not the issue. The junction capacitance will determine the off time. The 2N3904/2N3906 transistor pair meet the on/off timing requirements.

**POWER SUPPLIES**

There are four supply signals necessary to implement all functions of the OBD-121 / ECU-121 and they are all derived from the vehicles OBD connector $V_{BATT}$ supply.

- 12V – Taken directly from the $V_{BATT}$ supply fused at ½ amp. This supply is used to derive all other supply voltages and is limited according to SAE J1962 to 4 amps. If using an external power supply, connect only regulated power or add a regulation circuit to maintain 11.5 – 13.5v.
- 5V – Derived from the $V_{BATT}$ supply through a 5v regulator. The chip requires a clean regulated 5v supply. Total current requirements for this application is < 100mA.
- 2.5V – Derived from the 5V supply by resistor divider network. This supply is used as a comparator reference and requires < 1ma.
- 9V – Used for VPW transmit. Derived from $V_{BATT}$ using a zener diode – resistor shunt. This supply is used to transmit VPW signals to the vehicle. The 1kOhm shunt resistor and active signal level combine to draw ~15mA.

**LED SIGNALING**

Several outputs are available for use as visual queuing to tell the user what the OBD-121 / ECU-121 is doing. Whilst the OBD-121 / ECU-121 will directly sink 20ma per output, it is recommended that all signals be buffered through an external transistor.

**OSCILLATOR**

The OBD-121 / ECU-121 requires a 20mhz fundamental frequency crystal oscillator to ensure signal timing is correct. It is recommended that an Epson CA301 series quartz crystal be used with 18pf load capacitors. This is the crystal used while developing this chip and will guarantee proper signal timing. Due to the dependence of these chips on timing, each microcontroller is supplied with a crystal.

Figure 1: Example Circuit

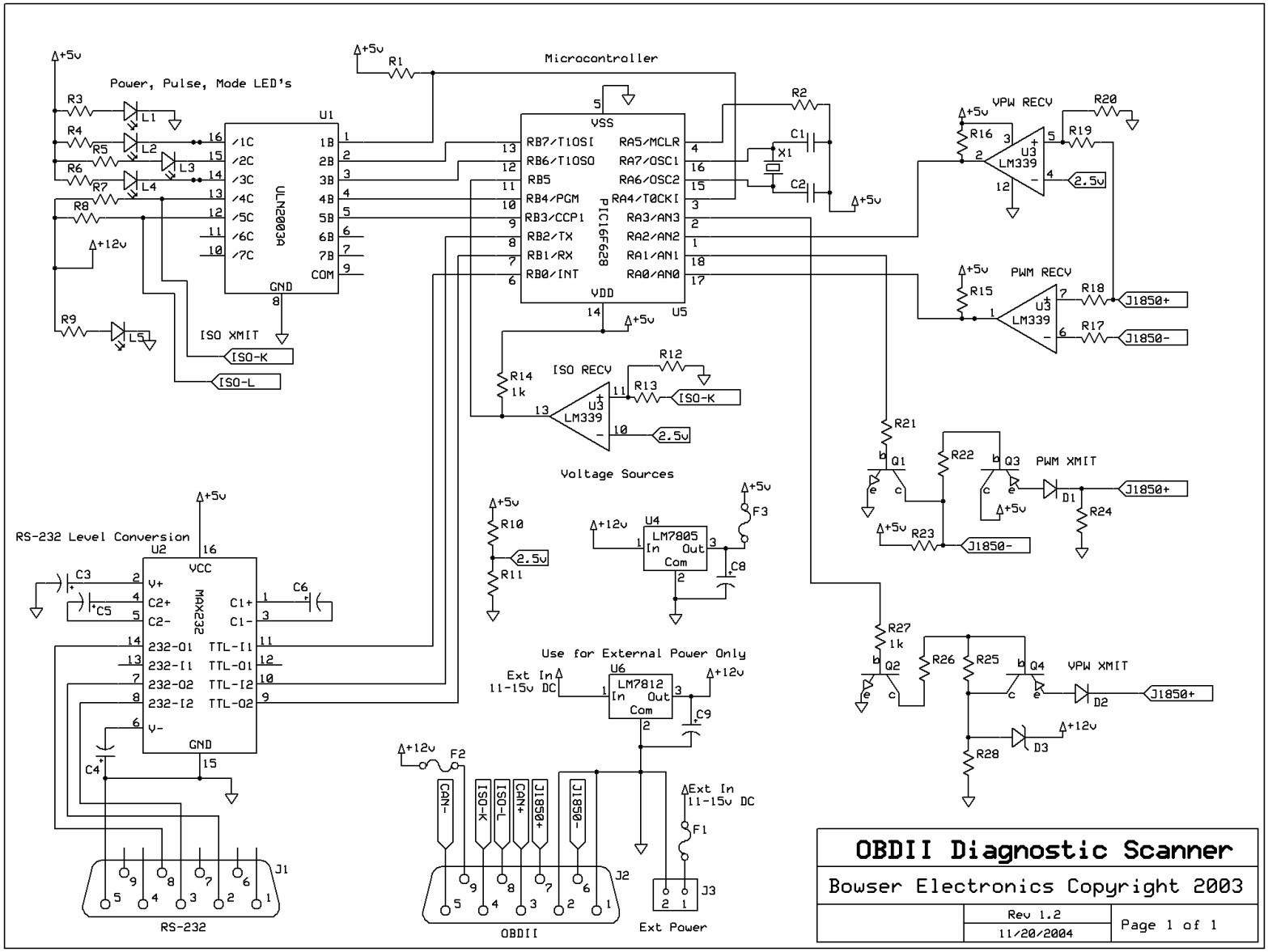

Table 2: Parts List

| Part | Value |
|---|---|
| C1 | 18pf |
| C2 | 18pf |
| C3 | 1uf |
| C4 | 1uf |
| C5 | 1uf |
| C6 | 1uf |
| C8 | 10uf |
| C9 | 10uf |
| D1 | 1N4148 |
| D2 | 1N4148 |
| D3 | 1N4733A |
| F1 | .250A |
| F2 | .250A |
| F3 | .250A |
| J1 | DB9F |

| Part | Value |
|---|---|
| J2 | DB9M |
| L1 | LED |
| L2 | LED |
| L3 | LED |
| L4 | LED |
| L5 | LED |
| Q1 | 2N3904 |
| Q2 | 2N3904 |
| Q3 | 2N3906 |
| Q4 | 2N3906 |
| R1 | 1k |
| R2 | 10k |
| R3 | 1k |
| R4 | 1k |
| R5 | 1k |

| Part | Value |
|---|---|
| R6 | 1k |
| R7* | 510 |
| R8* | 510 |
| R9 | 1k |
| R10 | 10k |
| R11 | 10k |
| R12* | 6.2k |
| R13* | 10k |
| R14 | 1k |
| R15 | 1k |
| R16 | 1k |
| R17 | 10k |
| R18 | 10k |
| R19 | 10k |
| R20 | 22k |

| Part | Value |
|---|---|
| R21 | 1k |
| R22 | 1k |
| R23 | 2.2k |
| R24 | 2.2k |
| R25 | 10k |
| R26 | 1k |
| R27 | 1k |
| R28 | 1k |
| U1 | ULN2003A |
| U2 | MAX232 |
| U3 | LM339 |
| U4 | LM7805 |
| U5 | PIC16F628 |
| U6* | LM7812 |
| X1 | 20MHz |

Note: All Resistors ¼ W
For OBD-121, F1 and U6 are not required

For ECU-121, use the following:

R7 = 100kΩ
R8 = Not Used
R12 = 22kΩ
R13 = 47kΩ