Proposal for Skyline OBD-II Retrofitting

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1 Introduction

This document serves to outline a potential method for resolving the issue of a lack of OBD-II interface support in the Nissan Skyline, required for "Federalization" [1] of cars with 1996 or subsequent model years. Although specifically targeted towards the Skyline, the procedures outlined in this document should be trivial to apply to other Nissan models with similar built-in support systems to the Skyline.
A summary of requirements for this retrofit hardware in order of importance are as follows:

1. Full OBD-II Compliance (as required for Federalization).
2. Require no major modifications to the stock Skyline harnesses/ECU.
3. Be cost-effective to implement.

Requirement 2 is put in place because major wiring/ECU changes potentially compromise the reliability of the car, and increase the labor costs of the conversion. Completely replacing the ECU/wiring harness (e.g. use an existing OBD-II compliant ECU[2]) is an option, but this has the same disadvantages as major modifications to the stock system. In addition, retaining the stock ECU/wiring looms allow for the use of aftermarket modifications designed specifically for the Skyline, and keeps the car in close specification with the Factory Workshop Manuals.

Title	*Description*
SAE J1962	Diagnostic Connector Equivalent to ISO/DIS 15031-3:December 14, 2001
SAE J1979	E/E Diagnostic Test Modes
SAE J2012	Diagnostic Trouble Code Definitions
ISO 9141-2:1994	Part 2: CARB requirements for interchange of digital information
ISO 14230-4:2000	Part 4: Requirements for emission-related systems
CA FRO 1968.1	1994 – (California) Malfunction and Diagnostic System Requirements
CA FRO 1968.2	2004 – (California) Malfunction and Diagnostic System Requirements

Figure 1: Reference information.

2 Applicable Standards

This paper depends on several standards for reference, listed in Figure 1. California Air Resource Board (CARB) standards have been chosen over the EPA guidelines because of California being at the forefront of emissions control of "motor vehicles". Conforming to California's requirements assures "50 state" legality.

[1] In this case referring to the US Federal Government EPA conformance requirements.
[2] For example, the McKinney/JWT solution of using the VG30DETT ECU with the Skyline as briefly described in SCC0309.

3 Retrofit Responsibilities

The hardware/software in the retrofit kit are responsible for implementing all aspects of OBD-II compliance. This compliance has several aspects; they can be summarized as the following:

- Providing ISO 9141-compliant electrical interface(s).
- Complying with SAE J1979 protocols.
- Implementing applicable SAE J2012 Diagnostic Trouble Codes.
- Implementing appropriate CA FRO 1968.1 policy (e.g. DTC generation and MIL illumination).

In the case of the Skyline, the primary regions of interest in CA FRO 1968.1 policy are:

- Catalyst Monitoring.
- Ignition/Misfire Monitoring.
- Evaporative System Monitoring.
- EGO Monitoring.
- PCV Monitoring.
- MIL Control.

Monitoring is required to detect potential problems with the emissions system. Policy defined in CA FRO 1968.1 explicitly specifies conditions under which DTCs must be generated/cleared, and how the creation/clearing of DTCs impacts the illumination of the MIL.

4 Implementation Overview

The design of the retrofit hardware is centered around the use of a microcontroller to:

- Gather information from the vehicle required to make policy decisions.
- Make said policy decisions.
- Update internal state, and make external changes (e.g. MIL).
- Provide information to OBD-II standard requests.

4.1 Hardware Overview

The diagram in Figure 2 provides a basic block diagram of the relation of the hardware interfaces.

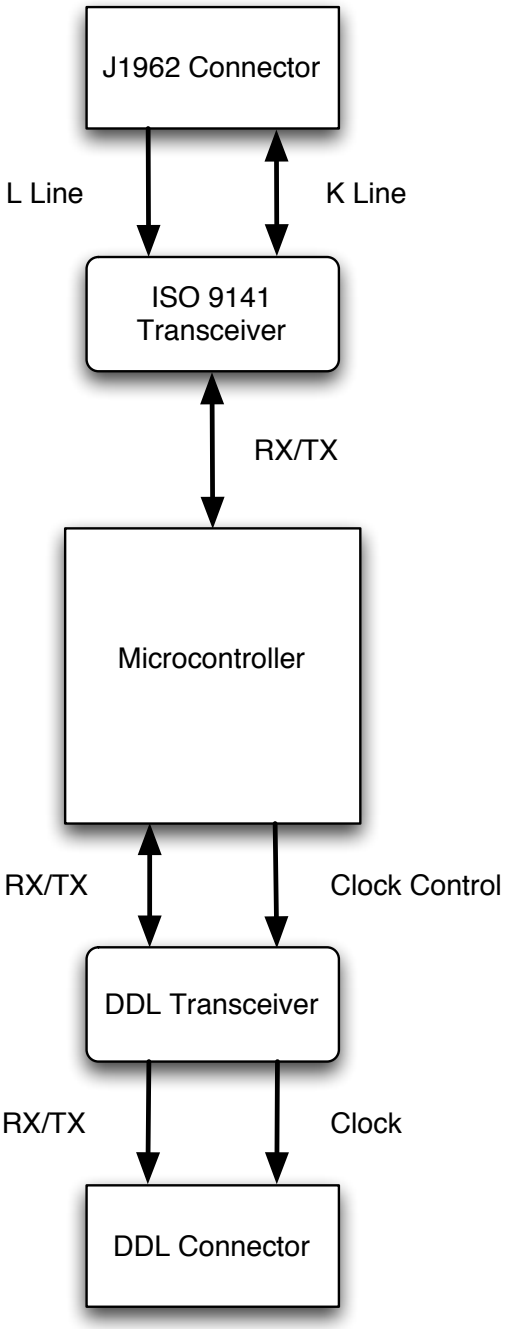

Figure 2: Interfacing block diagram.

4.1.1 Vehicle Interface

In order to fulfill the responsibilities of the system, the retrofit system must have access to the necessary information regarding the systems to be monitored. The Skyline ECU comes equipped from the factory with a proprietary Diagnostic Data Link, common to most of Nissan's product line. This port allows the assembly line and repair facilities to verify the status of the vehicle's subsystems and diagnose potential problems. This DDL should be capable of providing all information required to make appropriate OBD-II policy judgments.

Interfacing with the DDL is well understood, and requires minimal hardware to implement. Communication with the DDL requires supplying a free running clock at 16 times the datarate. Serial communication are asynchronous. The transmission line from the DDL is an open-collector configuration, while the reception line has Vbatt (e.g. +13.8V) and chassis ground as levels. Standard practice is to interact with the DDL at 9.6kb/s. With the appropriate transceiver, an off-the-shelf universal asynchronous receiver/transmitter (UART) will interact properly with the DDL.

4.1.2 OBD-II Interface

In order to comply with the OBD-II requirements, the retrofit hardware must comply with one of the supported electrical standards. ISO 9141-2 is well understood, used by Nissan in OBD-II compliant vehicles, and has a readily available supply of support components.

Interfacing using the ISO 9141-2 specification requires an appropriate transceiver, and a UART with the capability of self-clocking at 10.4kb/s.

4.1.3 MIL Interface

MIL operation must be controlled by the hardware, so a mechanism must exist for controlling an arbitrary lamp or LED. Either high or low side switching could be supported, with low side being preferable.

4.2 Software Overview

The software included in the retrofit kit would exist as firmware executing on the embedded microcontroller. The firmware's mainloop would consist of the following:

1. Collect the current vehicle system status via the DDL.
2. Handle pending OBD-II commands.
3. Process all incoming data against defined CA FRO 1968.1 policy.
4. Generate DTCs as necessary.
5. Save status freeze-frames as required.

6. Update MIL status.

7. Sleep for required time (e.g. 20ms).

Interrupt handling routines would be required for event timing, to wake on incoming OBD-II requests, and wake on DDL information.

4.2.1 DDL Interaction

Nissan's DDL supports a generic set of registers from the factory for all manner of status information (e.g. O2 sensor voltage) and control (e.g. on-the-fly timing changes). In addition to the generic registers, there are vehicle-specific status and control registers.

In order to properly implement all of the required OBD-II policy (e.g. specific cylinder misfire detection), it may be required to reverse engineer the ECU's firmware in order to determine memory locations for specific pieces of information. This should be facilitated through the flexibility of the DDL protocol, allowing the reading of arbitrary RAM and ROM locations out of the ECU without hardware modifications.

4.2.2 OBD-II Interaction

In order to fully support OBD-II, all appropriate aspects of SAE J1979 must be implemented. These include but are not limited to:

- ISO 9141-2 Timing Requirements.
- Data Not Available Policy.
- Requests for current powertrain information.
- Requests for powertrain freeze-frame information.
- Requests for DTCs.
- Requests to clear/reset DTCs.
- Requests for emissions monitoring tests (e.g. EGO status).
- Requests for pending DTC information.
- Requests for vehicle test/systems control.
- Requests for general vehicle information (e.g. VIN information).

5 Implementation Notes

5.1 Components

In order to comply with the requirement of being cost-effective to implement, this retrofit kit must be designed using off-the-shelf components. With the use of Surface Mount Technology (SMT) and appropriate in-house testing/fabrication techniques, combined component, PCB, and enclosure costs should be less than 100 USD in quantities of 25 or more.

Two available microcontrollers which would be well suited to the task of driving the retrofit system are the 8-bit Atmel AVR mega128, and the 32-bit Philips ARM LPC2129. Both are capable of all communication requirements, with the AVRmega128 providing easier/cheaper prototyping, and the LPC2129 providing higher performance and more RAM/ROM.

DDL transceivers can be built from a combination of discrete components and integrated circuits. Existing DDL interfaces designed for software such as the ConZult have been built using MAX232s in concert with other components. DDL connectors are available, but scarce. Fabrication of a batch of connectors may be required for a production run.

OBD-II transceivers are available as fully Integrated Circuits (ICs) from Infineon, Motorola, and others. They support all of the electrical requirements of ISO 9141-2, and provide a complete inexpensive hardware solution for interfacing with microcontrollers. Female J1962 connectors are available in bulk from several sources.

5.2 Development Timeframe

Due to the highly experimental nature of the topics discussed in this document, it is difficult to generate an accurate timeframe for implementation. Based on a "wild assed guess", a two engineer team would take one work month to have a prototype developed, when equipped with access to:

- Several Skyline ECUs.
- A Skyline test car (e.g. 1996 Skyline R33).
- Loading-capable chassis dynamometer (e.g. Dynapack).
- Several OBD-II scan tools.
- Electronics lab (e.g. SMT rework station, 100 MHz oscilloscope, EEPROM reader/writer).
- Hardware development tools (e.g. CADSoft's Eagle, Protel).
- Software development tools (e.g. UNIX workstation with cross-compilers).
- Availability of a smog shop with professional smog testing equipment for late-stage testing.

In the case of the availability of one engineer, a two-month timeframe would be possible.

6 Conclusion

This document defines one possible route for bringing the Nissan Skyline into compliance with US EPA/California ARB OBD-II requirements. The process of retrofitting the stock diagnostic port, as described here, provides a means by which the Skyline electrical system is kept as stock as possible, while at the same time providing an extremely cost-effective mechanism for conversion.