Fuel Injection Monitor System (FIMS) MK II

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Introduction

The fuel injection monitor system (FIMS) is designed to be fitted next to the dash board of a vehicle running the combination of a Rover V8 and 14CUX (Hot Wire) fuel injection system. FIMS allows the driver to dynamically view the state of the lambda signals while also viewing a range of live data read from the 14CUX ECU. It generates a new road speed signal for the 14CUX to suit the non standard combination of fuel injection and Land Rover Series III gearbox and drive train. FIMS requires four sets of connection to the vehicle loom. One to pick up power, one to deal with road speed sensing (in and out), one to connect to the 14CUX diagnostics serial port, and one to collect raw data from the two lambda probes. The system is split into two units. The analog unit is a small black box with three connectors and a power light fitted close to the 14CUX ECU. The processor unit contains keypad, LCD display screen and the processor logic and is fitted to the left of the dash board.

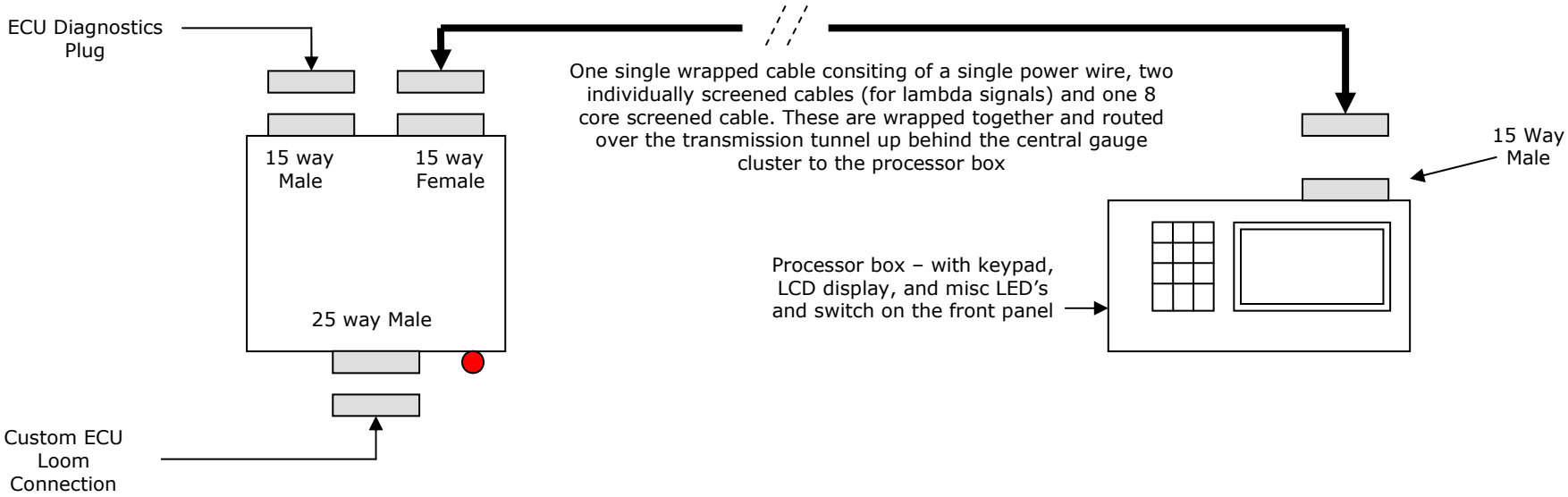


Figure 1 – Layout of the analog and processor/display units – which together make up FIMS

Cables

There are three cables used on this system described as follows:-

Diagnostics Connection cable between the analog interface and the 14CUX serial port

Description:

The 14CUX extends its serial port via a 5 pin TTS connector…

The loom socket has a plug cap inserted into it – and which essentially grounds the 14CUX serial receive wire (in order to make sure the 14CUX doesn't mistake electrical noise for a communications packet). Unfortunately, 5 pin TTS connectors are extremely hard to obtain. Therefore a hard wiring connection was made directly between the wires entering the TTS connector using soldered joints and heat shrink and a separate 15 way female D type (which is itself plugged into the analog interface unit).

This cable is relatively short (about 12" long) and note that in order to use the connection the earth blanking plug must be removed from the 14CUX TTS connector socket on the loom.

15 Way Female Connector	Loom connection on the existing TTS connector	Description
Pin 1	Black wire	Ground
Pin 3	Green/White wire	This signal originates from ECU pin 9 and is the 14CUX serial port transmit wire
Pin 4	Red/White wire	This signal originates from ECU pin 18 and is the 14CUX serial port receive wire

Figure 2 – Serial link cable wiring

Analog interface to processor unit cable

Description:
This cable connects the analog interface unit (located in the battery compartment of the vehicle), to the dash mounted processor box.

This cable is roughly 2mtrs long, and consists of four cables wrapped together. One power cable, a pair of separately screened cables (to carry the buffered lambda signals), and a single 8 core screened cable to carry the remaining signals. The three earth screens (two from the lambda cables, and one from the 8 core cable) are commoned to form a ground. D type connectors terminate both ends of the cable with the end terminating near the 14CUX being male, and the end at the dash board being female.

Note that wiring adheres to the normal D type pin numbering conventions (refer to appendix A). Pin number "n" at one end will connect to pin number "n" at the other.

15 Way Female Connector	Description
Pin 1 and Pin 2	12V – using heavy 7amp 1mm CSA Power cable in yellow
Pin 13 and pin 14	Screen of the 8 core cable, and the screen of both lambda signal cables.
Pin 15	Lambda left signal
Pin 12	Lambda right signal
Pin 3	14CUX serial port transmit signal
Pin 4	14CUX serial port receive signal
Pin 5	EFi Check light (the signal issued by the 14CUX when a "check engine" fault occurs. Note this is active low.
Pin 6	Engine electric cooling fans on (this signal is +12v when the engine cooling fans are running).
Pin 7	Raw road speed transducer signal – as read from the transducer fitted in line with the speedometer cable
Pin 8	Road speed output signal. This is a 5v signal output from the processor unit and sent to the analog interface unit – which then uses a darlington pair to amplify the 5v signal to swing between 12v and ground. That signal is in turn fed out from the analog unit as an input to the 14CUX system in order to control when the vehicle switches to idle.
Pins 9, 10 and 11	Spare

Figure 3 – Cable wiring between the analog unit and the processor

Breakout cable for the injection loom

Description:
This cable extends a set of signals from the 14CUX ECU loom, and was carefully added to the loom when the 14CUX was originally added to the vehicle. It terminates in a 24 way female D type connector located physically close to the 14CUX main plug. Note that the FIM system does not require all of these signals. Those that are not used by the FIM are shaded in gray.

25 Way Female Connector	Description
Pin 1,2 and 3	Ground
Pin 4	Main relay sink drive (ECU pin 12)
Pin 5	Main relay output (ECU pin 2)
Pin 6	Fuel relay sink drive (ECU 19)
Pin 7	Fuel relay output (to fuel pump)
Pin 8	Road Speed Transducer signal output from the FIM box and fed as an input to the 14CUX. Note that this signal is generated by the FIM processor unit.
Pin 9	Left injector sink drive signal (ECU 13)
Pin 10	Right injector sink drive signal (ECU11)
Pin 11 & 12	Spare
Pin 13	Raw road speed signal from the transducer fitted in line with the speedometer cable (note that the transducer is a two wire unpolarised device, and the other wire connects directly to 12v)
Pin 14	Spare
Pin 15	Ignition switched +12v
Pin 16	Engine cooling fans activation signal (which is +12v when the engine cooling fans are running)
Pin 17	EFi check engine warning signal. This is the ECU signal that normally connects to a lamp on the dash board to drive a "check engine" style warning light. Note that this is an active low signal
Pin 18,19 & 20	Spare
Pin 21	Lambda left screen wire (ie: ground)
Pin 22	Direct connection to the Lambda left signal wire (passenger side)
Pin 23	Spare
Pin 24	Direct connection to the Lambda right signal wire (drivers side)
Pin 25	Lambda right screen wire (ie: ground)

Figure 4 – ECU loom break out cable wiring

FIMS Analog Interface Unit

The analog interface unit consists of a box with three connectors, a power LED, and a small (and very simple) circuit board. The primary purpose of this unit is to provide three high impedence amplifiers with which to monitor firstly the left and the right lambda O^2 sensor signals, and secondly the raw road speed transducer signal. An additional darlington pair amplifier is used to amplify the 5v road speed signal from the processor to +12v which is then fed out to the 14CUX as the road speed input.

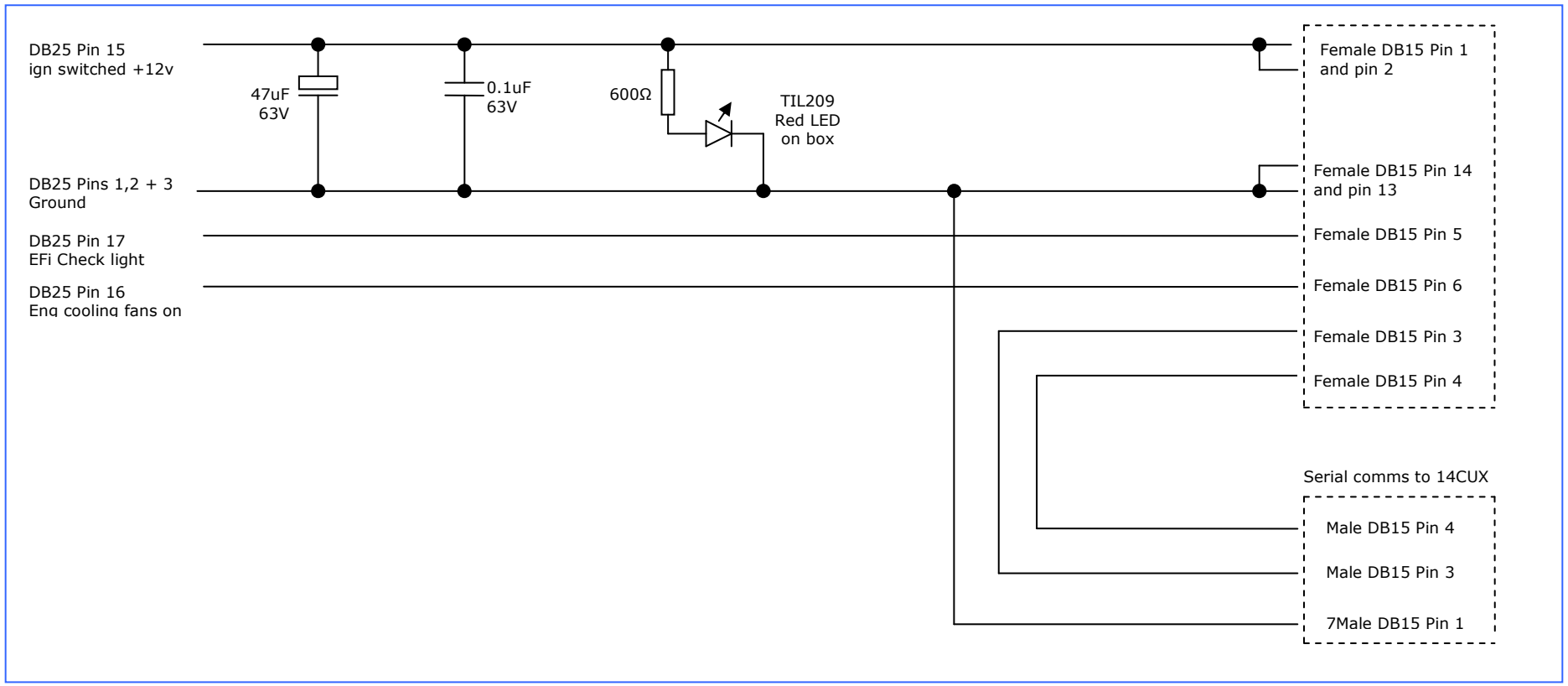


Figure 5 – Analog interface unit - Straight through connections and power (schematic 1 of 2)

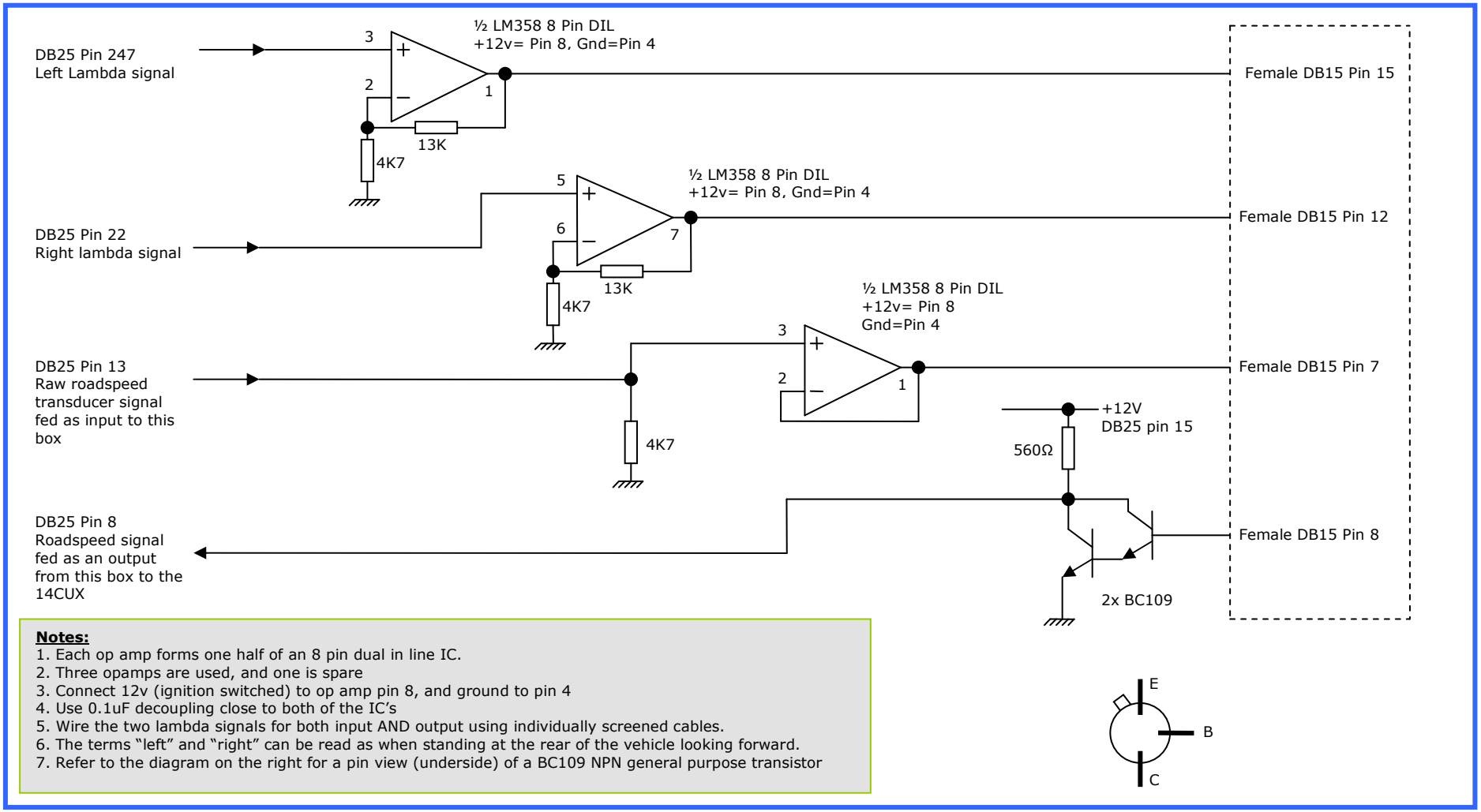


Figure 6 – Analog interface unit - High impedence buffers and darlington driver (schematic 2 of 2)

FIMS Processor Unit

The processor unit is designed to be dash mounted. It contains an illuminated keypad, a backlit but dimable LCD display, and a set of four front panel LED's. The logic is relatively simple consisting of a crystal oscillator module, a single quad two input nand gate (74LS00) and a PIC microcontroller of type 18F4620.

The quad two input nand is used primarily as a buffer (to isolate the PIC chip from the 14CUX) but has a secondary function of acting as a 12v inverting interface. The raw road speed signal transducer outputs a 12v signal which passes through a potential divider before being passed into one nand and then to the PIC chip. Additionally the 14CUX serial port transmits a 12volt signal, but which is also inverted and so that signal has to be interfaced and complimented before being passed to the PIC (note that the 14CUX receive signal requires a non inverted +12volt signal, but in practice a 5volt signal drives it perfectly well).

The project complexity is hidden within the software programmed into the PIC chip. The key features of the PIC chip employed by this project are…

1. Large eprom space (64K bytes)
2. Large RAM space (by microcontroller standards 3968 bytes is huge)
3. E^2PROM (1K bytes) for long persistent state
4. Built in I^2C bus
5. Fully programmable Asynchronous UART with interrupt support
6. Timer counters with extensive interrupt support
7. Fast analog to digital convertion with interrupt support

The PIC chip is programmed using the Microchip ICD3 system employing the short flying lead (inside the processor unit) with an RJ45 plug on the end. The software is written in C, and consumes 18KBytes of ROM and 142 bytes of RAM. E^2PROM is used to hold persistent state data.

Processor Unit – Front Panel LED Wiring

The processor box has four LED's mounted on the front panel (two amber, one green and one red). These are wired onto a small PCB with current limiting resistors and a small eight wire loom as shown below. The two amber LED's are connected to the processor and can be used freely for debug by altering the software. The green LED illuminates when the engine cooling fans are switched on. The red LED illuminates when the 14CUX activates its EFi "check engine" warning light.

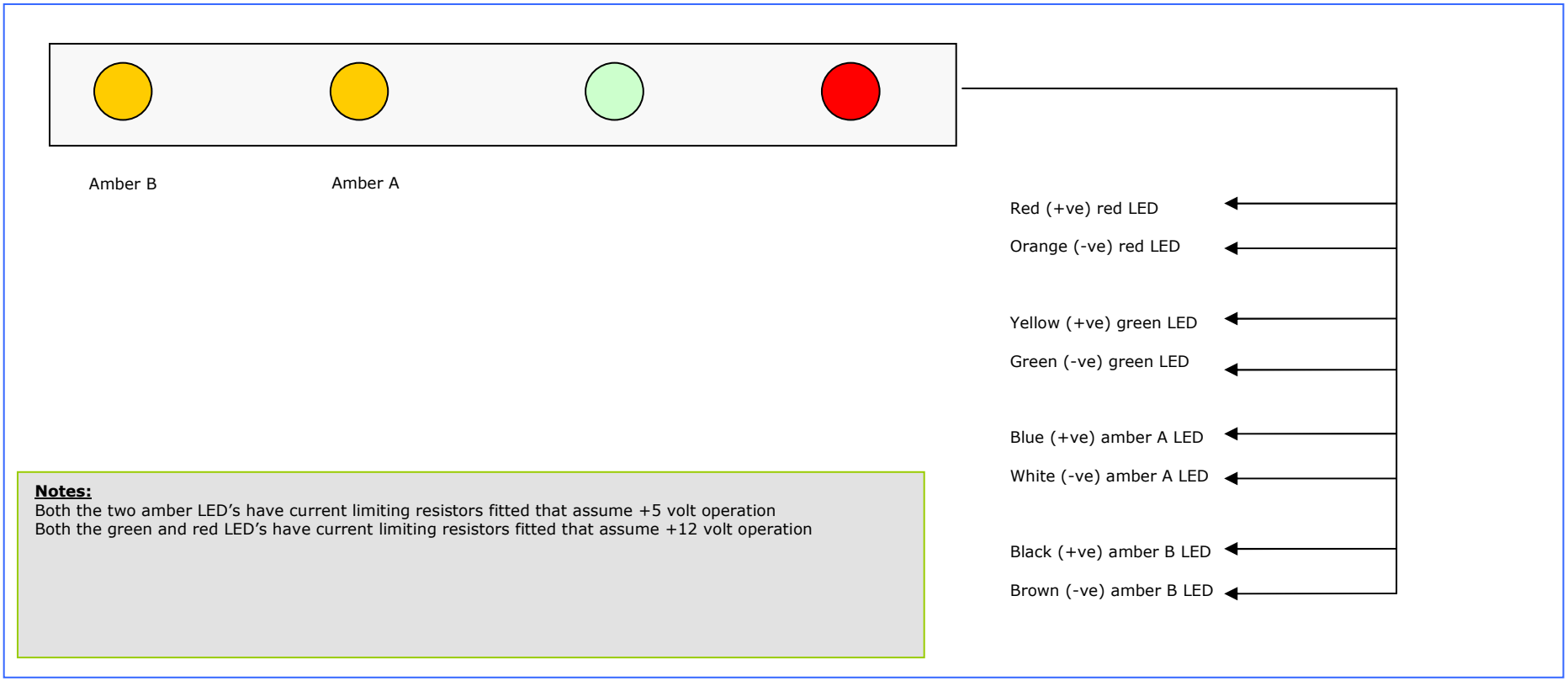
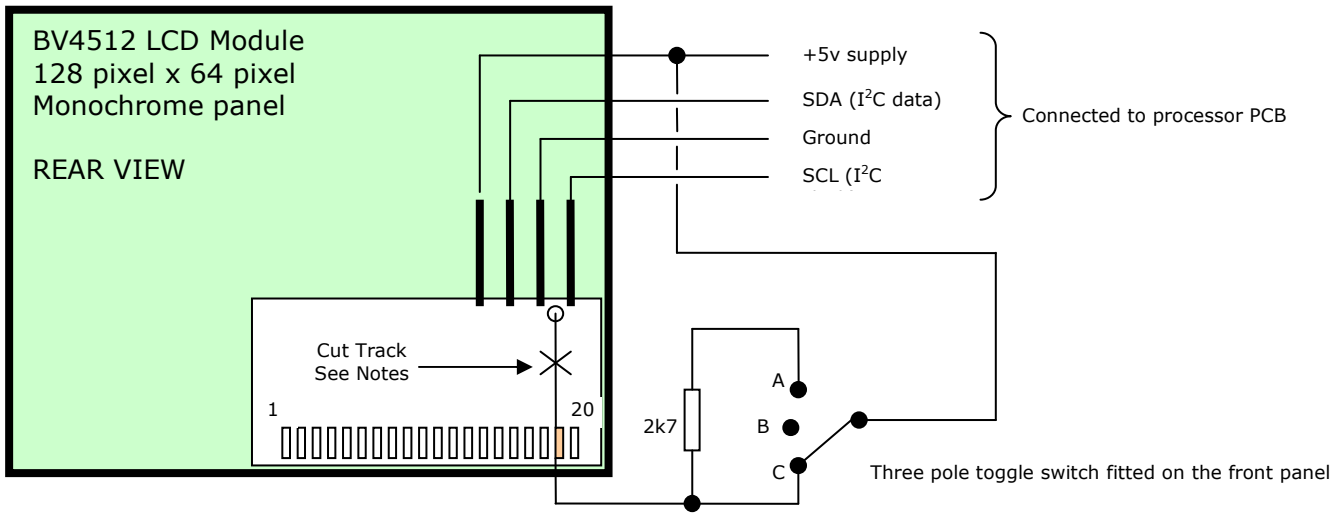


Figure 7 – Front Panel LED wiring in the processor unit

Processor Unit – LCD Wiring

The processor unit includes a BV4512 LCD module. This 128 x 64 pixel monochrome panel is capable of displaying 21 characters on 8 lines. It comes fitted with a controller board which also includes a 400Khz I^2C interface. The LCD panel is fitted with a fixed LED backlight which is unfortunately too bright for night time use in a vehicle. The unit has been modified so that the backlights can be dimmed.



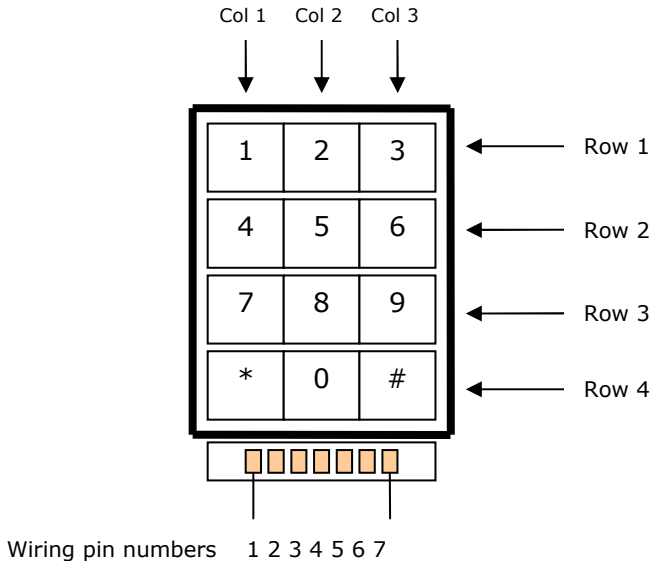
Notes:
The LCD backlights are too bright for night time driving. Carefully cut the track linking the PCB through hole to pin 19 on the small I^2C circuit board mounted on the back of the LCD panel. This track actually connects the backlight (on pin 19) to +5v. Run a new wire from pin 19 to a three way switch as shown

Position (A) runs the backlight in a dim "night time" mode
Position (B) switches the backlight off altogether
Position (C) runs the backlight in full brilliance mode.

Figure 8 – Front Panel LED wiring in the processor unit

Processor Unit – Keypad Wiring

The processor unit includes a dumb keypad with characters 0 to 9, star and hash. The seven wire connector has three wires for the individual columns, and four for the rows. The keypad is not debounced.



Pin Description

Pin 1 – Column 2
Pin 2 – Row 1
Pin 3 – Column 1
Pin 4 – Row 4
Pin 5 – Column 3
Pin 6 – Row 3
Pin 7 – Row 2

Notes:
The keypad has more than 7 holes drilled into the key side of the PCB which can be a little misleading. Refer to the copper solder pads to locate pin 1 closest to the star character.

Figure 9 – Front Panel LED wiring in the processor unit

Processor Unit – Schematic.

The processor unit schematic is shown on the following page. The circuit board contains a set of pins which act as soldered connectors. The wiring to the LCD panel, the keypad, the LED's and the 15 way D type are soldered to these connectors. The connections are shown below.

Processor PCB Conn1	
Description This connector links the processor unit to the LCD display panel. It consists of a two wire I^2C interface, along with power and ground	
Pin 1	Serial data line (SDA) for the I^2C interface
Pin 2	Serial clock (SCL) for the I^2C interface
Pin 3	+5volts
Pin 4	Ground

Figure 10 – Processor unit PCB Conn1 (LCD panel power and I^2C bus connection)

Processor PCB Conn2		
Description This connector links the processor unit to the four front panel LEDs		
Pin	**Signal**	**Description and what it connects to**
Pin 1	RDO	Brown wire carrying the sink drive signal RD0 to –ve of Amber (B) LED (Left amber LED on front panel)
Pin 2	+5v	Black wire carrying +5v to the +ve side of the Amber (B) LED (Left amber LED on front panel)
Pin 3	RD1	White wire carrying the sink drive signal RD1 to –ve of Amber (A) LED (Right amber LED on front panel)
Pin 4	+5v	Blue wire carrying +5v to the +ve side of the Amber (A) LED (Right amber LED on front panel)
Pin 5	Fans ON	Yellow wire carrying the drive signal from the engine fans to the +ve side of the green LED
Pin 6	Gnd	Green wire carrying ground to the -ve side of the green LED
Pin 7	EFi Warning	Orange wire carrying the sink drive for the 14CUX EFi check light to the –ve side of the red LED
Pin 8	+12v	Red wire carrying +12v to the +ve side of the red LED

Figure 11 – Processor unit PCB Conn2 (connection to front panel LEDs)

Processor PCB Conn3

Description
This connector links the processor unit to the keypad – with a straight 7 pin wiring configuration

Figure 12 – Processor unit PCB Conn3 (keypad connection)

Processor PCB Conn4

Description
This connector links the processor unit to the block of 6 LED's mounted above the keypad and designed to illuminate the keypad when a key is pressed. The underside of the LED block includes one current limiting resistor per LED.

The wiring is shown in the schematic below.

Pin	Signal	Description and what it connects to
Pin 1	+5v	Supply
Pin 2	RB7	Sink drive signal – must be current limited to 30mA max.

Figure 13 – Processor unit PCB Conn4 (keypad illumination LED drive)

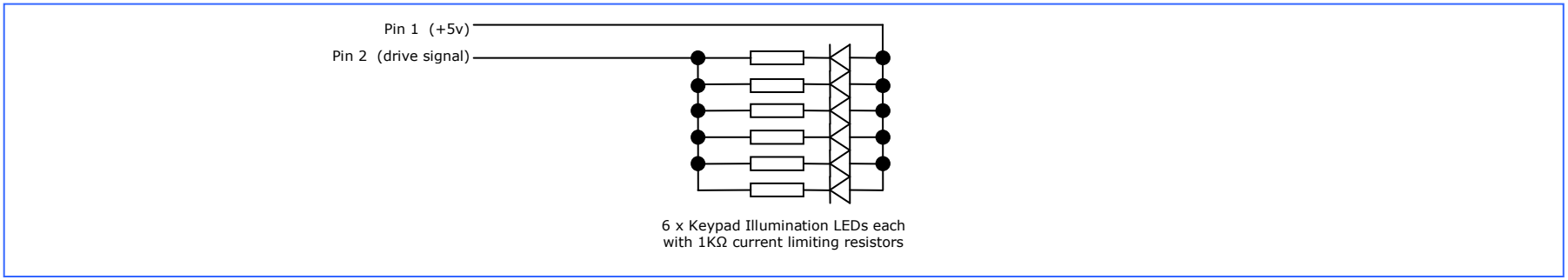


Figure 14 – Schematic of keypad illumination LEDs

Processor PCB Conn5

Description
This connector is actually a floating cable with an RJ45 plug – and is the mechanism used by the ICD3 system to program the PIC 18F4620 processor chip.

Pin	Signal	Description and what it connects to
Pin 1	+5v	Yellow on a standard Microchip PIC break out cable
Pin 2	/MCLR	Blue on a standard Microchip PIC break out cable
Pin 3	PGM data	Red on a standard Microchip PIC break out cable
Pin 4	PGM Clock	Black on a standard Microchip PIC break out cable
Pin 5	Ground	Screen on a standard Microchip PIC break out cable

Figure 15 – Processor unit PCB Conn5 (Microchip programming RJ45 cable)

Processor unit DB15 Chassis Mounted Male Plug

Description
This male chassis mounted connector is on the back of the processor unit, and (via the long linking cable) connects the processor to the analog unit.

Pin	Description
Pin 1 and Pin 2	ignition switched +12v
Pin 13 and pin 14	Ground
Pin 15	Buffered Lambda left signal
Pin 12	Buffered Lambda right signal
Pin 3	14CUX serial port transmit signal
Pin 4	14CUX serial port receive signal
Pin 5	EFi Check light (the signal issued by the 14CUX when a "check engine" fault occurs. Note this is active low.
Pin 6	Engine electric cooling fans operating (this signal is active high and is asserted when the cooling thermostat senses an over temperature condition).
Pin 7	Buffered raw road speed transducer signal – as read from the transducer fitted in line with the speedometer cable
Pin 8	Road speed output signal. This is the 5v signal output from the processor unit to the analog interface unit – which uses a darlington pair to amplify the signal to swing between 12v and ground. That signal is in turn fed as an input to the 14CUX system in order to control when the 14CUX switches the vehicle to idle.
Pins 9, 10 and 11	Spare

Figure 16 – Processor unit rear chassis mounted 15 way male D type

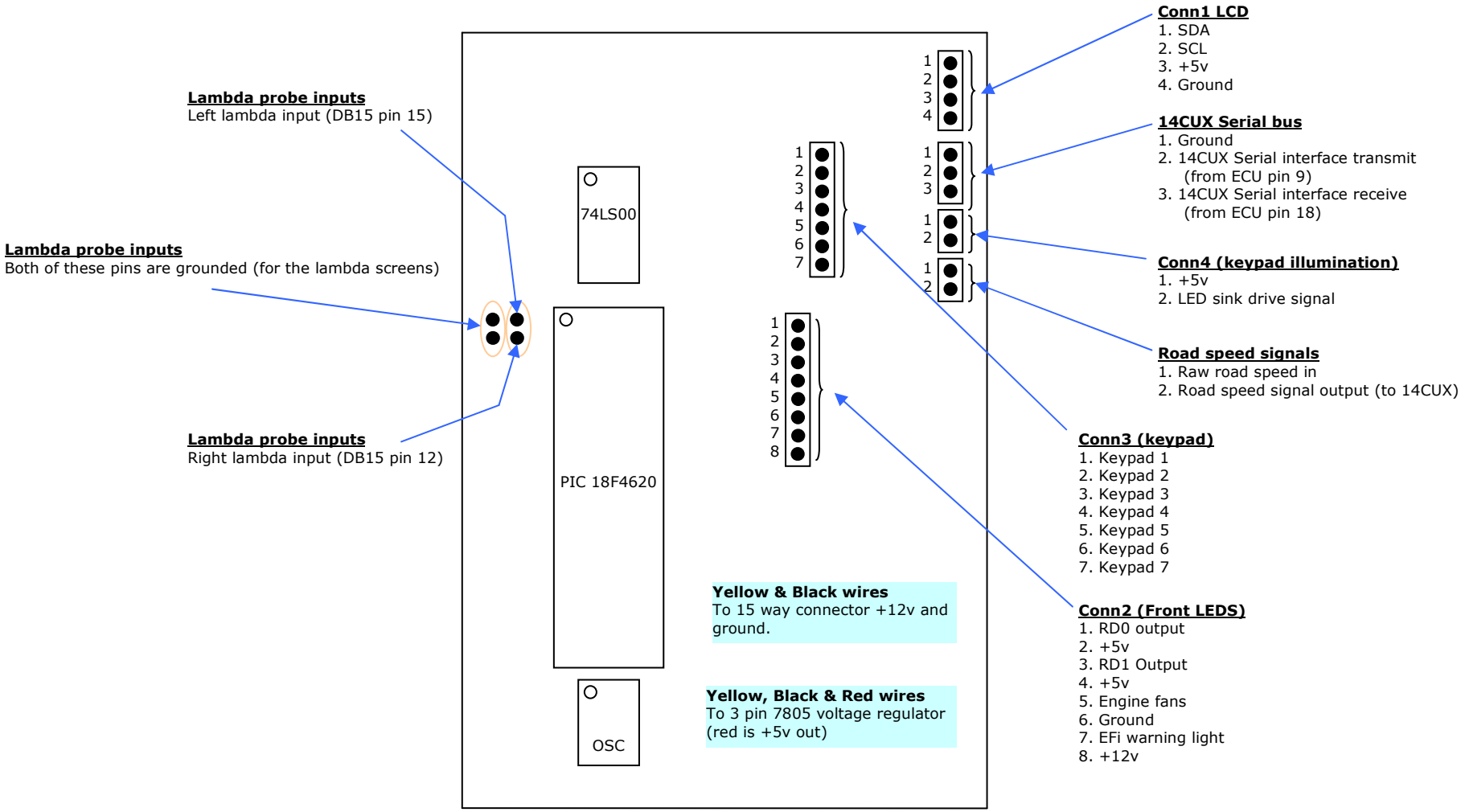


Figure 17 – FIMS Prototype PCB layout

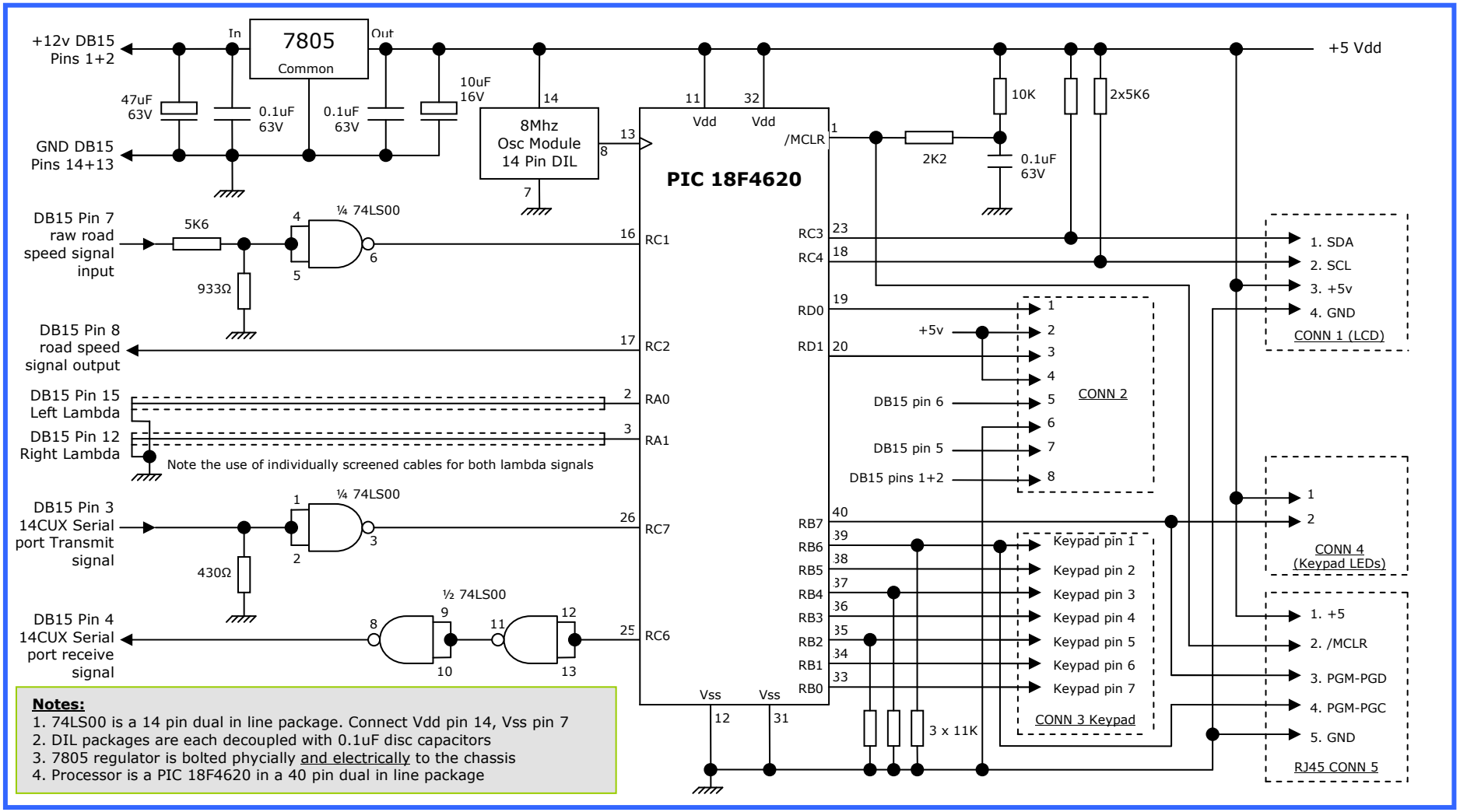


Figure 18 – FIMS Processor logic schematic

Appendix A – D Connector Pin Numbering

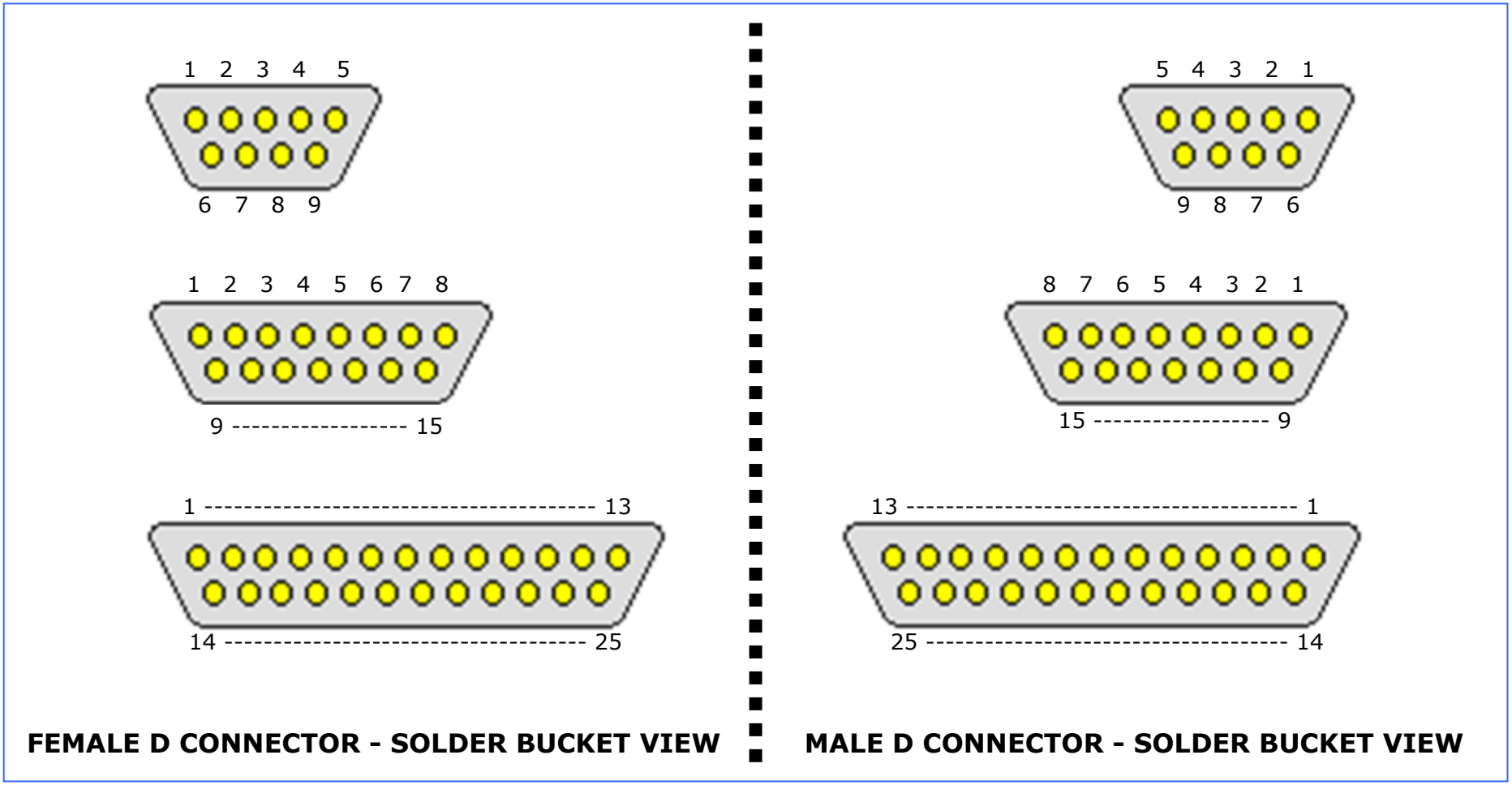
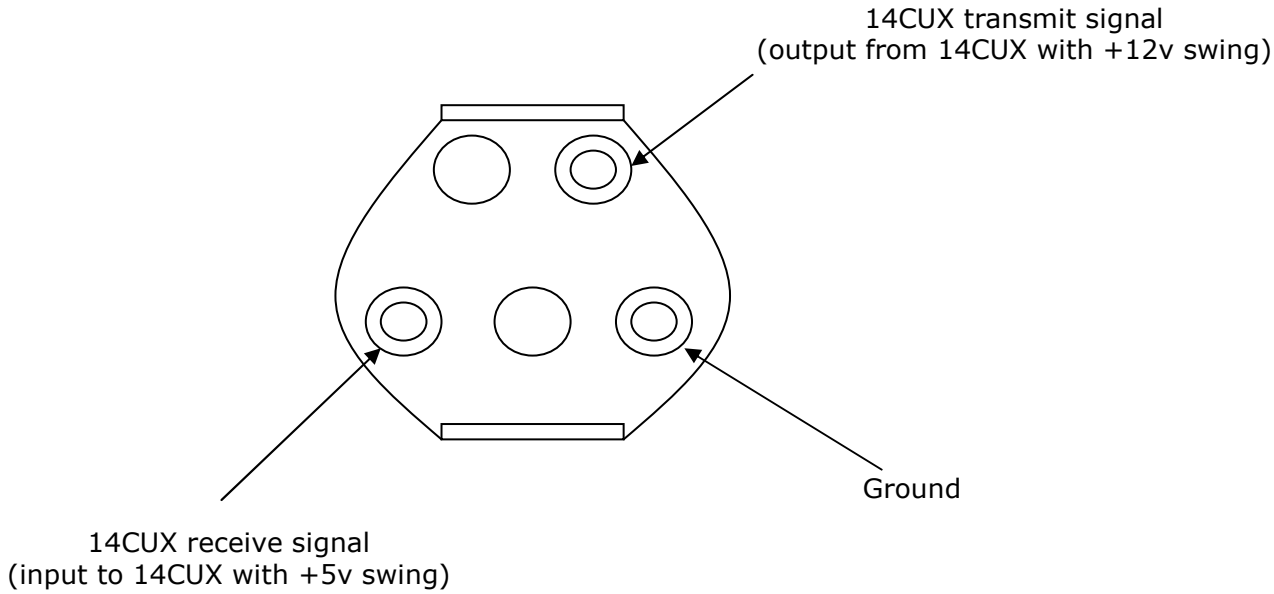


Figure 19 – D-Type Connector Wiring Pin Numbering

Appendix B – TTS Plug Wiring

When a diagnostic unit is plugged into the 14CUX TTS loom plug, the following wiring layout is used.



Notes:
This is the pin view looking at the diagnostics plug on the diagnostic reader (with the cable exiting at the rear). The mirror connections would apply to the socket on the ECU wiring loom.

Figure 20 – TTS wiring for a diagnostic unit