Ute Documentation: Hardware Manual

April 9, 2003

Chapter 1

Overview

TODO: Overview provides a high-level picture of the vehicle, labelling the various locations described in the sections below. Probably want photos of front-side (see Figure 1.1), and one photo of tray from above (see Figure 1.3). Alternatively, have three orthogonal pictures: one from the front, one from the left-side (includes wheel encoder), and one from above. These pictures are marked with numbers to define the various sections, and a table is made of their names and section headings in this document.

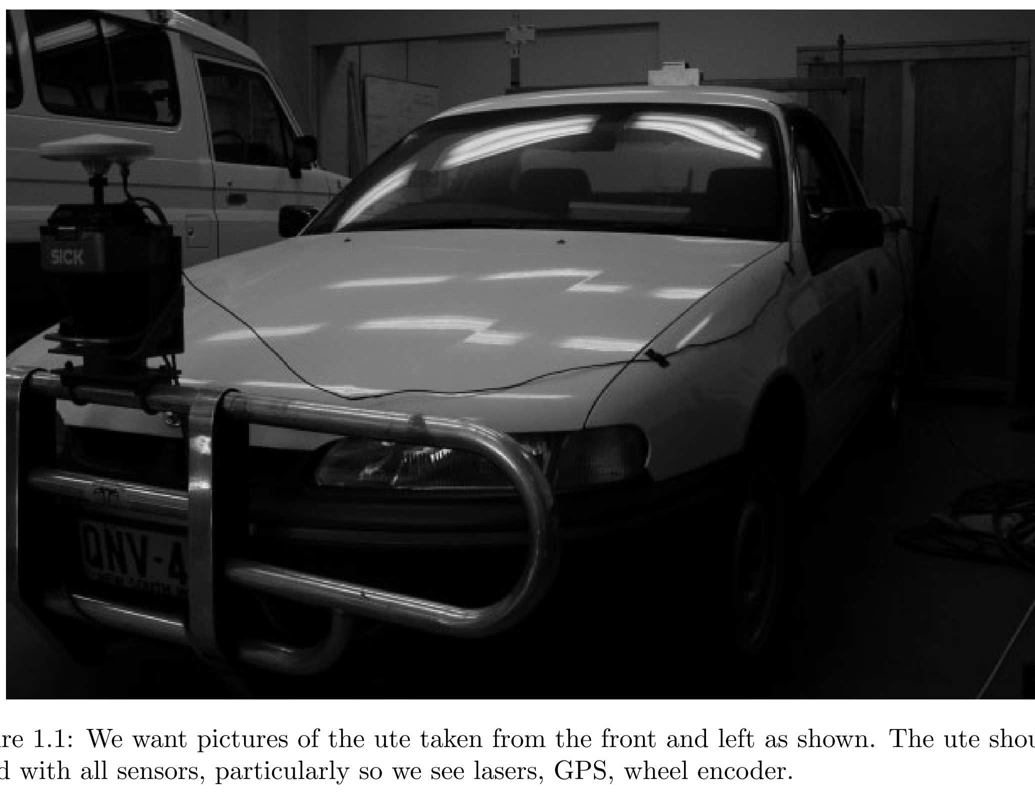


Figure 1.1: We want pictures of the ute taken from the front and left as shown. The ute should be fitted with all sensors, particularly so we see lasers, GPS, wheel encoder.

1.1 Overview of Component Locations

TODO: Table of component locations on the vehicles. The numbers in this table are keys to numbers on the ute photos. Further explanation of the contents of some components may be provided afterwards (e.g., what is in weatherproof box, which actuators are in the cab and where).

Components on the vehicle. (**TODO**)	
1. QNX box	5. Indoor laser—bumper
2. Weatherproof box	6. Outdoor laser—bumper
3. Actuators (in cab)	7. Outdoor laser—rollbar
4. IMU	8. GPS antenna
5. Wheel encoder	10. Batteries

TODO: In this document, significant redundancy (repetition) and cross-referencing is probably a good idea.

1.2 Manual Format

This document is composed of four main sections:

- Computer and Electrical Systems. Describes the QNX box, PC box, fuse rack, DC-DC voltage converters, power inverter, power amplifiers.
- Actuator Systems. Describes the steer, brake and throttle systems.
- Sensor Systems. Describes the lasers, cameras, GPS, IMU, gyro, compass, and wheel encoder systems.
- Connection Details Grouped According to Physical Location. This chapter provides a practical description of cabling and connections. Unlike the previous chapters, this chapter is not concerned with internal details such as electrical specifications. Rather, it describes components at an external level, grouped according to physical location, to facilitate piecing components together to produce a working system.

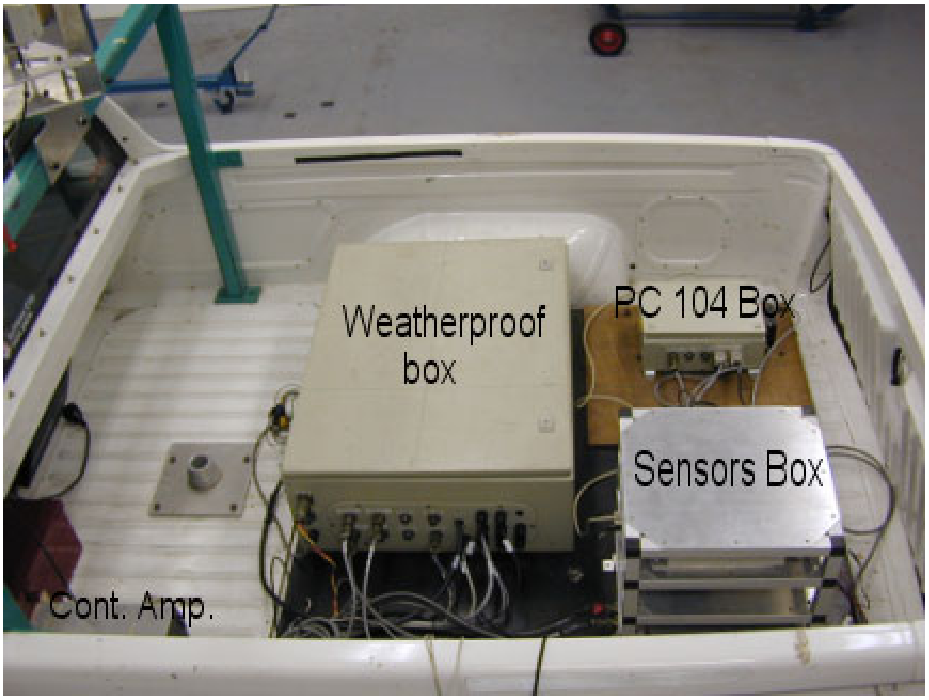


Figure 1.2: Ute tray. Here are highlighted the four basic components on the tray: the Pc 104 Box, the Wheatherproof box, the Sensors Box and the controllers amplifiers.

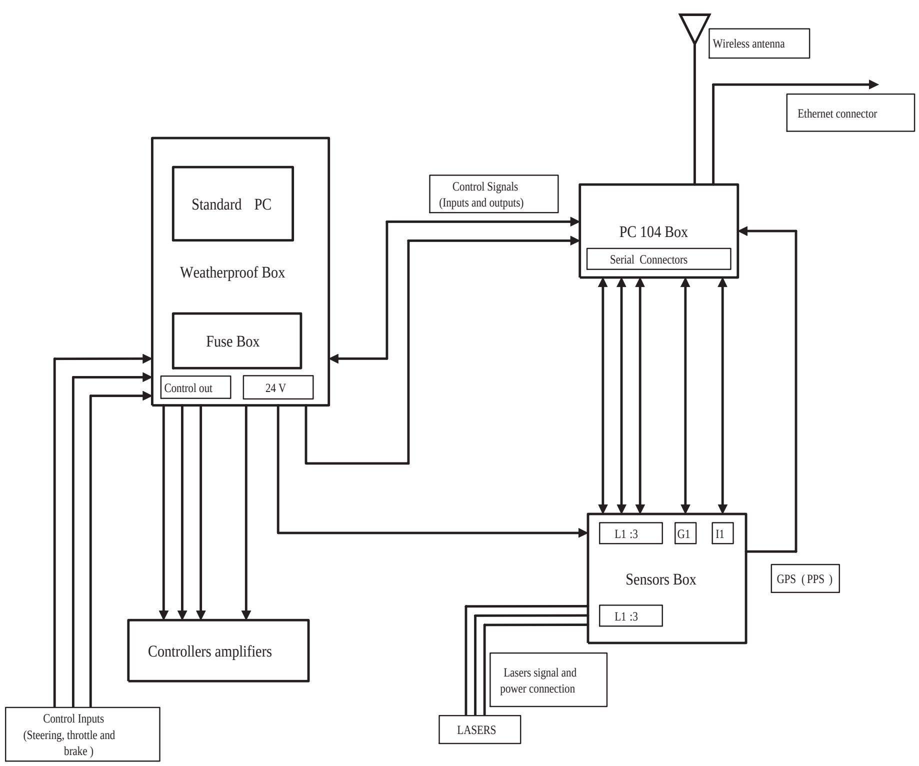


Figure 1.3: Schematic diagram of the ute tray.

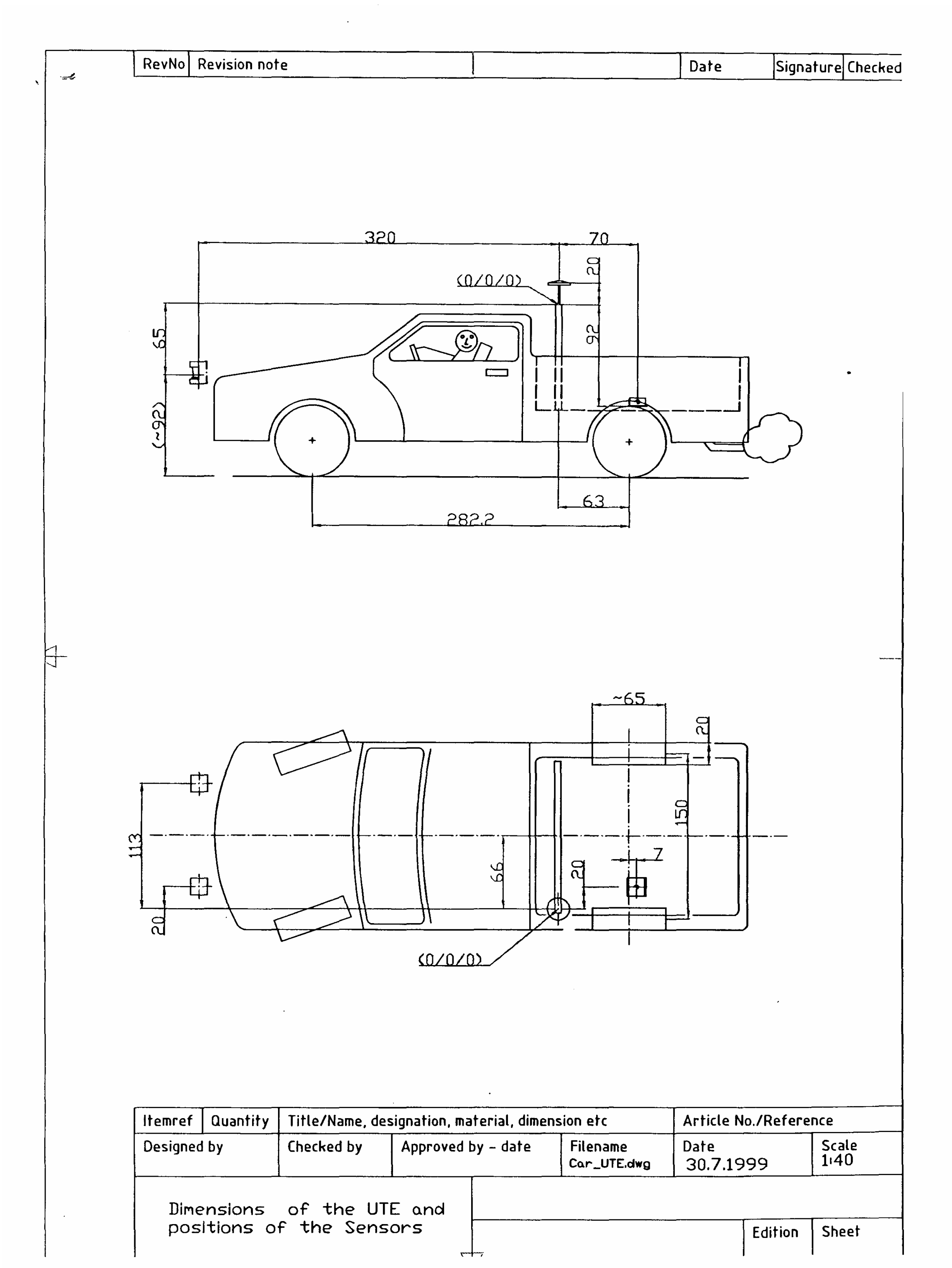


Figure 1.4: Diagram of overall ute dimensions. Some of the sensor location information may be obsolete, but the most salient dimensions remain correct. Note, perhaps more correct dimensions may be obtained from Juan's Ute Documentation paper.

Chapter 2

Computation and Electrical Systems

This chapter documents the various computational and electrical systems on the ute.

TODO: Document: Photos. Electrical schematics. Expected voltage and current specifications.

2.1 QNX Box

What's in it? PC104, wireless ethernet, GPS G8 card, ...

2.2 PC Box

What's in it? PCLabCard data acquisition board, standard PC components (serial, parallel ports)

2.3 DC-DC Voltage Converters

The two DC-DC voltage converters are the top two units in the weatherproof box rack (see Figure 2.1). The first converter is 24V to 12V rated at 2.1A (25W). The second is 24V to 5V (10A, 50W).

The connections to and from the DC-DC converters are shown in Figure 2.2(a). Note, all the input and output voltage lines are protected by fuses (see fuse card pinouts in Section 2.4 below). The input power comes from the ute batteries, which are located beneath a cover in the forward section of the tray. This power connects to the top-left connector on the weatherproof box.

The output from the 12VDC converter goes to the IMU power, the GG?? GPS transmitter, and the steering LVDT circuit. The output of the 5VDC converter goes to the GG?? GPS receiver, and ??whatelse??.

TODO: Update documentation of output connections to these converters so they reflect current setup. (I believe the schematic in Figure 2.2(a) is somewhat out-of-date.)

2.4 Fuse and Power Distribution Card

List the pins (screw connectors) for each fuse. We have the schematic, but need a more physically-oriented diagram.

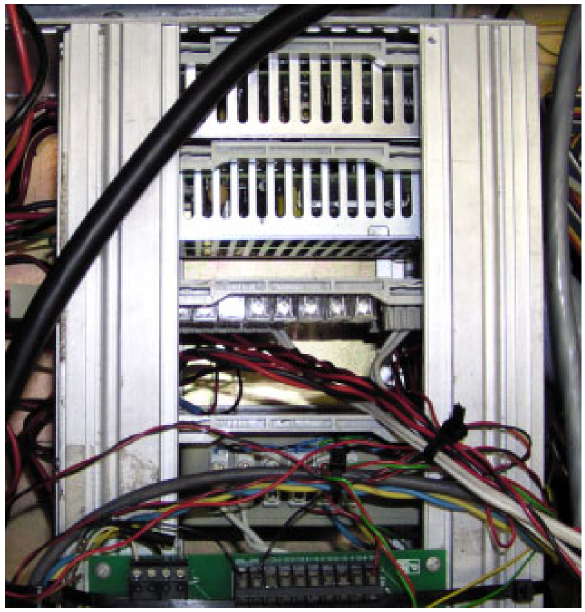


Figure 2.1: Weatherproof box rack. From top: two DC-DC voltage converters, fuse board, LVDT and velocity encoder board, and data acquisition patch board. Beneath the patch board is the Ashtech GG24 GPS card.

2.5 LVDT and Velocity Encoder Board

The fourth card in the weatherproof box rack (i.e., below the fuse board) is the LVDT and velocity encoder board. This board sends power to the steering LVDT sensor (see Section ??), and receives signals from the LVDT sensor and the velocity encoder sensor (see Section 4.8). It performs two tasks: (i) it converts 12VDC to ±15VDC for use by the LVDT sensor, and (ii) it processes the velocity encoder signal from a variable-voltage variable-frequency sine-wave to a fixed amplitude (0–5V) variable-frequency square-wave.

A schematic of the connections to this board are shown in the middle-right of Figure 2.2(a). Here, the "steering LVDT" connector on the outside of the weatherproof box has six pins (A to F). Pins D and A are ±15V to the LVDT sensor, pin C is ground, pin B is the LVDT return signal, and pins E and F are the velocity encoder signal (a two-wire 'floating' signal).

The circuit on the LVDT and velocity encoder board is shown in Figure 2.3. The connector TB1 takes 12VDC and ground (pins 1 and 2) from the converter described in Section 2.3. This goes to a DC-DC converter and produces ±15VDC, which is output on connector TB2 (pins 3 and 4). The rest of the circuit shown is a pulse squaring circuit for the velocity encoder signal. This signal comes in on TB1 (pins 5 and 6) and the squared 5V pulse is output on pin 4 (with pin 2 as reference 0V). This pulse goes to the counter port on the data acquisition board (see Section 2.6 below). Notice that the return signal from the LVDT is not altered, and the voltage and ground (TB2 pins 1 and 2) are forwarded directly to the data acquisition analogue input (see Section 2.6 below).

2.6 Patch Board for PCLabCard

The bottom mounting on the weatherproof box rack is the patch board for the PCLabCard data acquisition board (see Figure 2.4). This patch board provides a screw-connector interface to digital and analogue I/O and an onboard counter. The actual data acquisition cards are located inside the PC box and are connected to the patch board via the five ribbon cables seen along the bottom edge

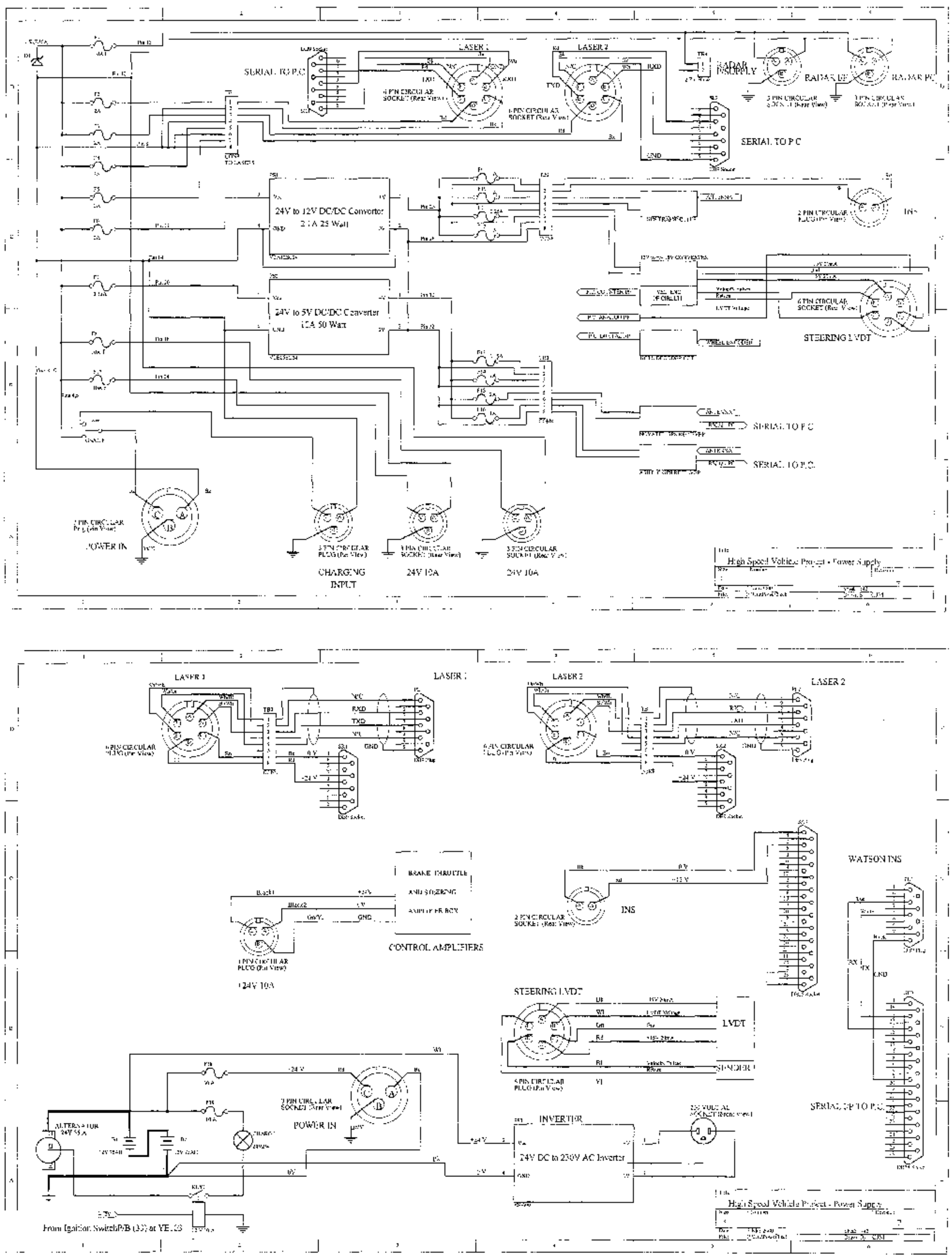


Figure 2.2: The top schematic (a) is of the power circuit inside the weatherproof box, and the bottom (b) shows (some of) the external connections to this box.

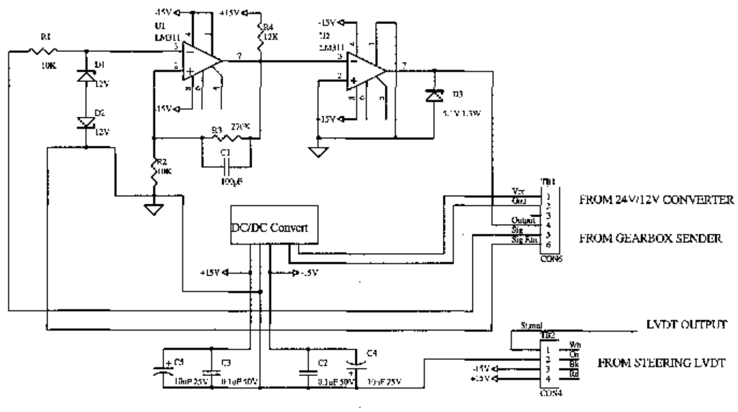


Figure 2.3: Schematic of the velocity encoder signal squaring circuit and 12VDC to 15VDC converter.

of the board.

The standard configuration of the patch board is written on the board itself. Some of these can be seen in the figure (e.g., analog in, digital out, etc), although most are obscured by the cable ties and by wiring. However, the current configuration is modified. One of the ribbon cables (the grey one) goes to a different data acquisition card, which provides additional analog outputs (i.e., digital to analog converters). This means that the two 8-pin connector blocks on the left top-edge no longer provide analog in, but now provide analog out. The exact pinouts of these two blocks is not currently known (?? have to check with Jose ??).

TODO: Describe the configuration of the patch board for all blocks as it is now configured. For example: analog IO, digital IO, wheel encoder counter and up-down counter chips, the other digital counter, the ribbon cables connecting to the two data acquisition cards.

Given the modified configuration, the connections to the patch board have been numbered in Figure 2.4 for identification below.

- 1. and 2. is the analog output control signal going to the throttle amplifier in the power amplifier box (see Section 2.8). This signal defines the setpoint for the throttle actuator. Wire 1 (red) is the signal voltage (0-??V, ??A), and it connects to pin 4 of the amp-box circuit board connector (see Figure 2.7). Wire 2 (black) is ground and it connects to pin 5 of the amp-box circuit board.

- 3. and 5. is the analog output control signal going to the brake amplifier in the power amp-box, defining the brake actuator setpoint. Wire 3 (green) is ground and goes to pin 9 of the amp-box circuit board. Wire 5 (white) is the signal voltage and goes to pin 8 of the amp-box circuit board.

- 4. and 6. is the analog output control signal going to the steering amplifier in the power amp-box, defining the steer actuator setpoint. Wire 4 (green) is ?? and goes to the pin (9 or 10??) of the white terminal strip in the top-left of the amp-box (see Figure 2.6). Wire 6 (white) is ?? and goes to the pin (9 or 10??) of the white terminal strip in the amp-box.

- 7. and 8. are digital outputs that are currently not being used for anything (I think).

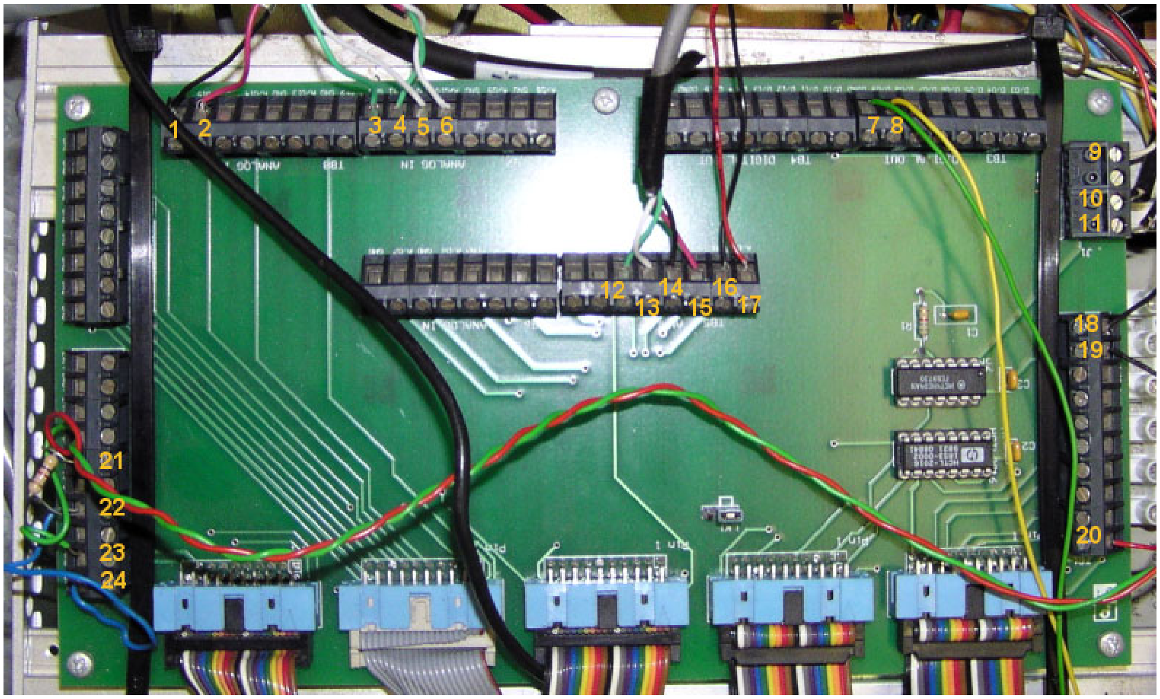


Figure 2.4: Data acquisition patch board.

- 9., 10. and 11. are the outputs from the wheel encoder sensor (see Section 4.7). Wire 9 (white) is ground. Wire 10 (??) is the channel A pulse signal, and wire 11 (??) is the channel B pulse signal. (Note, the supply voltage to the wheel encoder is not obtained from this patch board but is wired directly to ??where??.) These pins on the patch board go to an up-down counter, which counts the number of encoder pulses and uses the order of the leading edges of channels A and B to determine the wheel rotation direction.
- 12. and 13. is the analog input signal from the brake potentiometer, providing feedback of the brake actuator position. Wire 12 (green) is ground and goes to pin 14 of the amp-box circuit board connector. Wire 13 (white) is the signal voltage (0-??V) and goes to pin 11 of the amp-box circuit board.
- 14. and 15. is the analog input signal from the throttle potentiometer, providing feedback of the throttle actuator position. Wire 14 (black) is ground and goes to pin 14 of the amp-box circuit board connector. Wire 15 (red) is the signal voltage (0-??V) and goes to pin 10 of the amp-box circuit board.
- 16. and 17. is the analog input signal from the steering LVDT. Wire 16 (black) is ground and connects to pin ?? of the LVDT and velocity encoder board (see Section 2.5). Wire 17 is the signal voltage (0-??V) and goes to pin ?? of the LVDT and velocity encoder board.
- 18., 19. and 20. — I don't know ?? must find out ??
- 21. to 24. comprise a counter subsystem for counting the number of velocity encoder pulses (see Section 4.8). ** more here ** discuss this counter configuration.

2.7 Power Inverter

The 24V DC to 230V AC inverter is mounted in the ute tray on the rear wall of the cab.

TODO: - what is its current specification? - what is it used for? PC Box, laptops, etc.

2.8 Power Amplifier Box

The power amplifier box is bolted to the front-left-side of the tray, just behind the green roll-bar support (see Figure 2.5). This box contains the power amplifiers for the steering, throttle and brake actuators. It also has a circuit board to implement the throttle and brake manual override systems, and to provide reference voltages for the throttle and brake feedback potentiometers. A schematic of the amplifier box components is shown in Figure 2.6.[1]

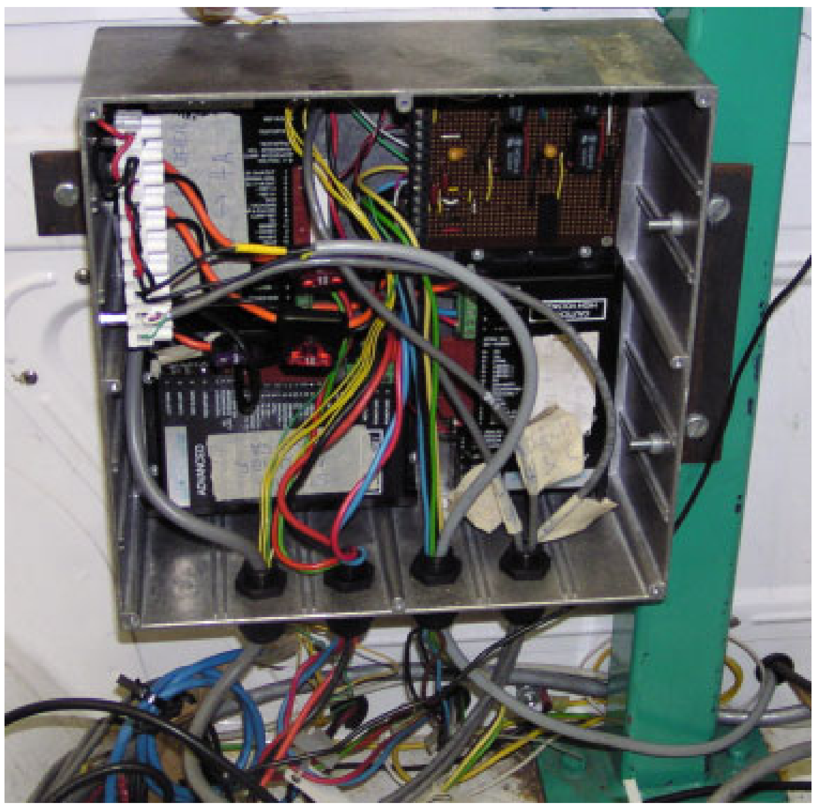


Figure 2.5: Power amplifier box.

The physical locations of the various components in the amp box are as follows (see Figure 2.6). At the top-left is a white terminal block. The top 8 pins of this block are alternately 24V and ground, and the bottom two pins are the steer actuator control signals from the data acquisition board in the weatherproof box (see Section 2.6). At the top-left, beneath the white terminal block, is the brake amplifier. At the top-right is the circuit board for the manual override circuit and potentiometer reference voltage circuit (see Figure 2.7). At the bottom-left is the steering amplifier, and at the bottom-right is the throttle amplifier.

The three power amplifiers are all 25A8 series PWM servo amplifiers from Advanced Motion Controls. They have been set to operate in "current (or torque) mode" where the amplifier output current is proportional to the input reference voltage.

[1] Much of the information for the amplifier box was obtained from Chapter 5 of the undergraduate thesis of L.C.K. Mok, 1998.

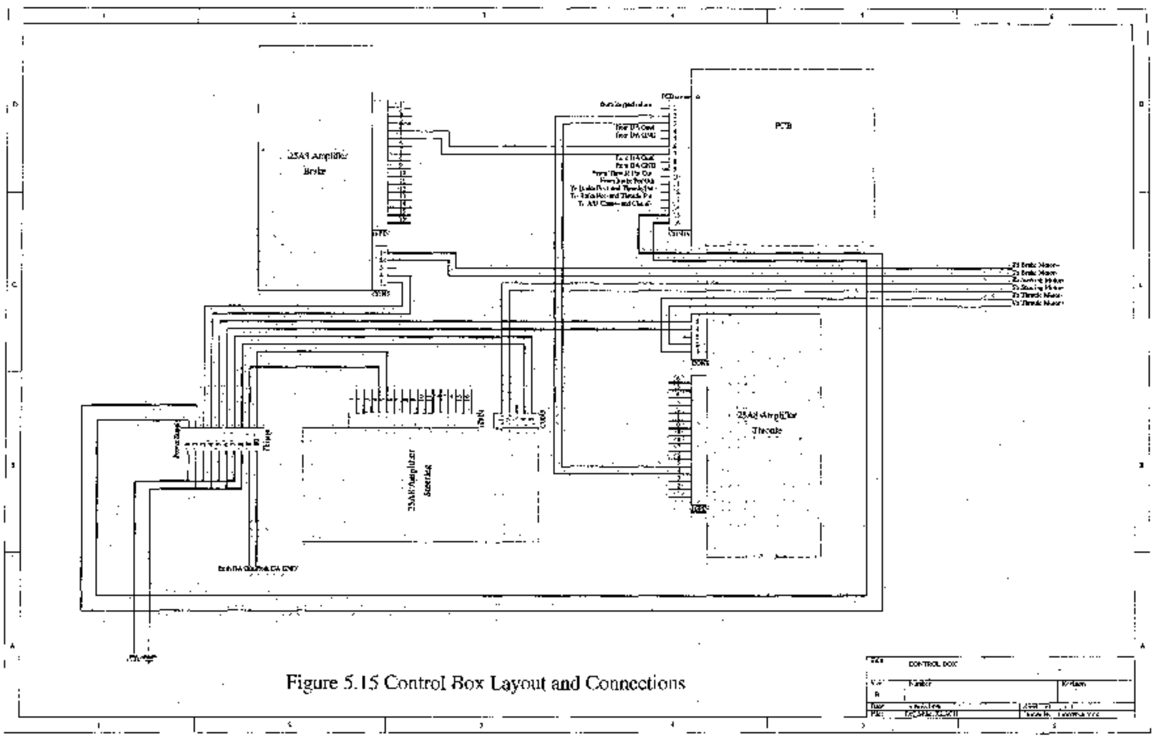


Figure 2.6: Schematic of the power amplifier box components and connections.

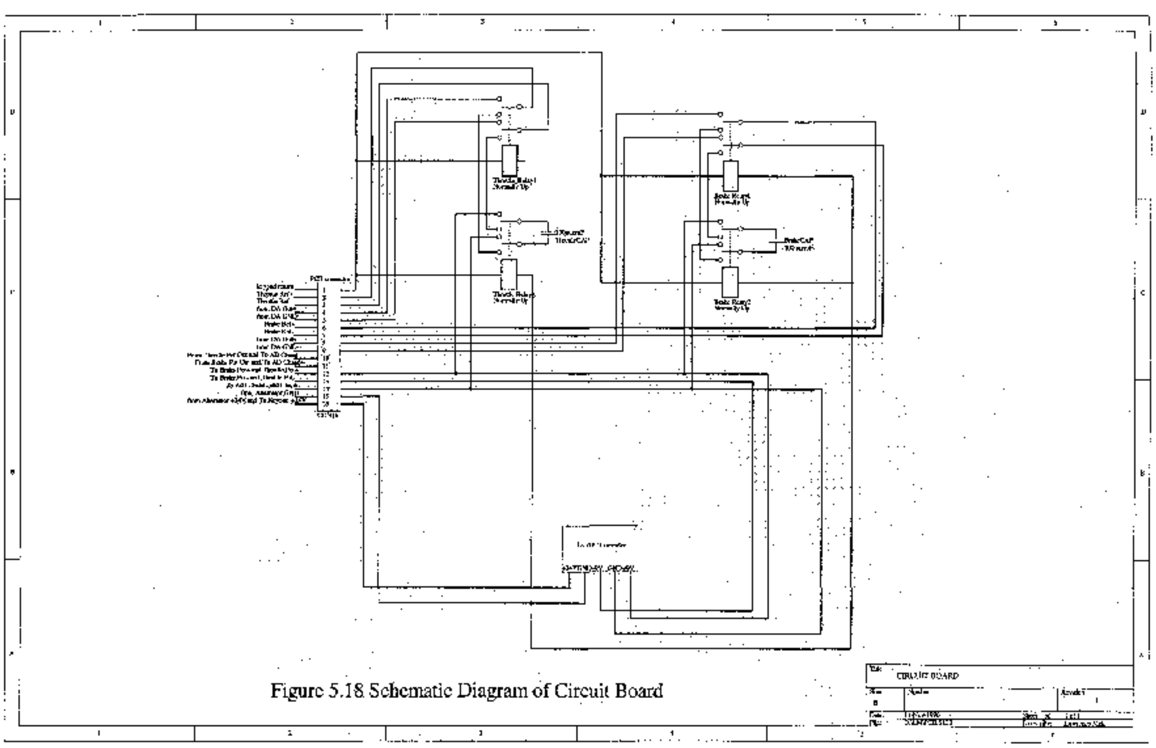


Figure 2.7: Schematic of the throttle and brake manual override circuit board. This circuit also provides reference voltages for the throttle and brake potentiometers.

TODO: Power amplifier calibration (page 56 of L.Mok's thesis). The amps are configured as current sources, and the characteristics of their output is tuned by a two-step process.

TODO: Show picture of manual override pad (taped to brake peddle). And discuss ... Also, discuss the pinouts for the circuit board connector (and refer to related sections).

Chapter 3

Actuator Systems

PDF documentation and manuals for the actuators described in this chapter can be obtained on the web from: http://www.acfr.usyd.edu.au/projects/research/ute/hardware.html.

Furthermore, these actuator systems are partially documented in Chapter 4 of the undergraduate thesis of L.C.K. Mok, 1998.

- control loop (processing,amp,actuator,feedback sensor)

3.1 Steering

- actuator (include diagram, page 22 of Mok's thesis) - LVDT: the web-page provides 2 equations for angle= f(LVDT). Which is the current one? - manual override (by way of torque-limiting clutch—Mok thesis, page 27—include diagram from this page)

3.2 Throttle

- actuator - potentiometer

3.3 Brake

- actuator - potentiometer

Tell Jossu to include the brake actuator and cable mechanism diagram from Mok's thesis.

Chapter 4

Sensor Systems

PDF documentation and manuals for the sensors can be obtained on the web from:
http://www.acfr.usyd.edu.au/projects/research/ute/hardware.html.

4.1 SICK Lasers

The ute has three lasers: two on the front bull-bar directed forward and horizontal (see fig 1), and 1 on the green roll-bar directed forward and at an incline towards the ground (see fig 2). In fig 1, the left laser is an outdoor version (LMS 221) and the right laser is an indoor laser (LMS 200).

TODO. Describe bolt-on mounts: Steel frame that bolts to back of laser casing. The base of this frame has a single bolt hole which attaches to a mounting frame on the bumpers and roll bar.

Tables of the salient characteristics of the two lasers are shown below.

SICK LMS 221 Specifications	
Maximum range	80m
Maximum functional range	Depends on surface reflectivity*
Maximum range at 10% reflectivity	30m
Range resolution	10mm ± 60mm
Angular sweep	180 degrees anti-clockwise
Angular resolution	0.5 degrees
Sweep period	??
Beam width	?? degrees
Power	24V ± 15%

*Graphs of reflectivity versus maximum range can be found on pages 7 and 8 of the LMS221.pdf manual.

Measurements are sent in the form of a byte stream via RS232.[1] For more information on the format of the message telegram consult the manual. Suffice to say here that a scan is transmitted as a set of 361 range measurements in centimetres.

TODO: Discuss connectors and relate to actual wiring shown in Figure 2.2. LMS 221 connector (16-pin): see Figure 4.2. LMS 200 connector—power (9-pin): see Figure 4.3. LMS 200 connector—

[1] The lasers may be configured to transmit either RS232 or RS422 (see the manuals for more information). Presently, they are set to send RS232.

Figure 4.1: This picture of the front of the vehicle will eventually have all the sensors attached so that the three lasers can be shown here labeled.

SICK LMS 200 Specifications	
Maximum range	50m?
Maximum functional range	Depends on surface reflectivity
Maximum range at 10% reflectivity	10m
Range resolution	10mm ± 30mm
Angular sweep	180 degrees anti-clockwise
Angular resolution	0.5 degrees
Sweep period	??
Beam width	?? degrees
Power	24V ± 15%

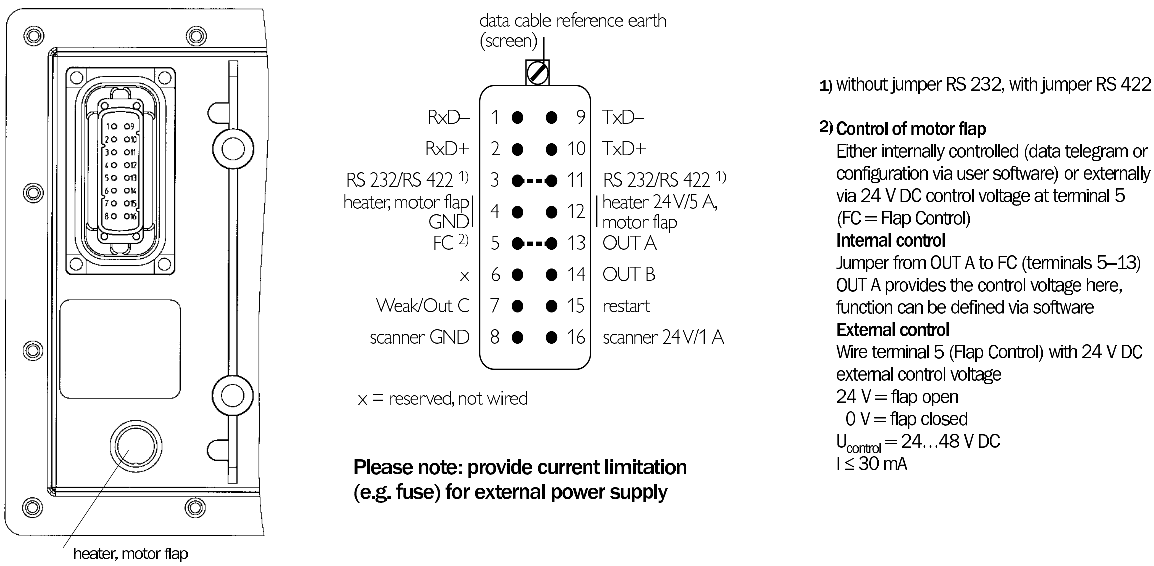


Figure 4.2: Connector pinouts for the SICK LMS 221 laser.

data (9-pin): see Figure 4.4.

4.2 Cameras

This section awaits Trevor's purchasing the new CCD sensors, and their configuration.

4.3 GPS

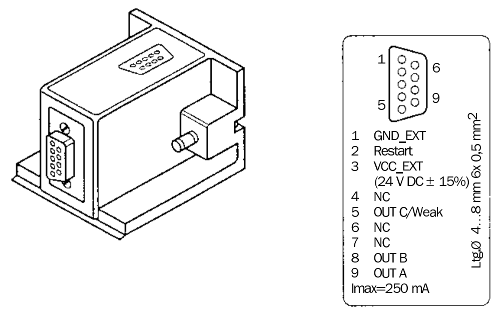
Ashtech GG24: - Where: Rack mount board in weatherproof box (alongside fuse rack). - Power and voltage: 2.3W receiver, 0.3W antenna, 5V DC ± 5% (see Juan's PDFs). - To find: connection pinouts...

Ashtech G8: - Where: in QNX box.

4.4 Watson IMU

TODO: The inertial unit (see fig 1 – show photo top and front) is bolted to ?where? in the ute tray. IMU location is subject to change. It seems likely the IMU will be placed in Juan's new serial

PIN	Signal designation	Input/ output	Wire colour
1	GND_EXT (earth)	–	brown
2	Restart	E	blue
3	VCC_EXT (24 V DC ± 15%)		red
4	NC	–	
5	OUT C/weak signal	A	grey
6	NC	–	
7	NC	–	
8	OUT B	A	turquoise
9	OUT A	A	orange



Please note: Provide current limitation (e.g. fuse) for external power supply

Figure 4.3: Power connector pinouts for the SICK LMS 200 laser.

PIN	Signal designation RS 232	RS 422	Input/ output
1	NC	RxD–	–
2	RxD	RxD+	E
3	TxD	TxD+	A
4	NC	TxD–	–
5	GND	GND	–
6	NC	NC	–
7	NC	jumpered	–
8	NC	RS 422	–
9	NC	NC	–

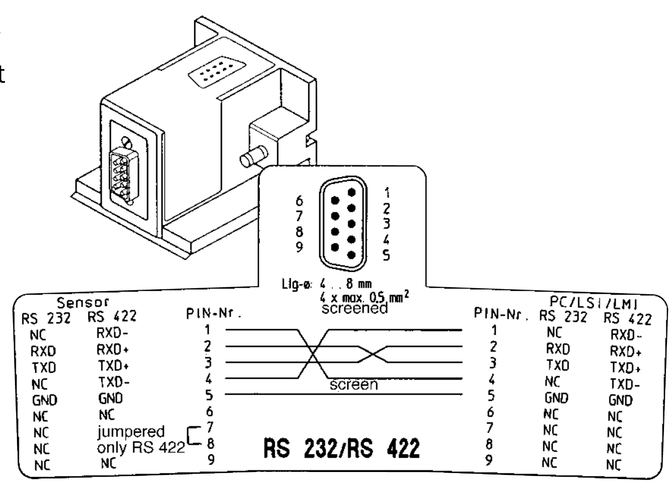


Figure 4.4: Data connector pinouts for the SICK LMS 200 laser.

box.

The IMU has two connectors on its front panel: a 25-pin male, and a 9-pin female. The 25-pin interface is for power and provides an analogue interface to all the inertial measurement information. The 9-pin interface is for RS232 serial data transmission. The pins for these two connectors are assigned as follows (consult the manual for more information).

25-pin Male Connector		
1. Power ground	12. Signal ground	20. Forward acceleration
2. +12 VDC	13. Reference command	21. Lateral acceleration
3–6. User inputs	14. Bank	22. Vertical acceleration
7. Velocity enable	15. Elevation	23. Roll rate
8. Coast command	16. Heading	24. Pitch rate
9. Not connected	17. X acceleration	25. Yaw rate
10. Initialisation command	18. Y acceleration	
11. Velocity input	19. Z acceleration	

9-pin Female Connector	
1. Not connected (N.C.)	4. N.C.
2. TX*	5. GND
3. RX	6–9. N.C.

* Note, the user receives on this line.

The current wiring on the ute does not make use of the 25-pin analogue interface—only the power pins 1 (0V) and 2 (12V, 600mA) are connected (see Figure 2.2). Pins 12 and 13 are tied together, and the remaining pins are floating. The cable for this IMU power interface plugs into an external connector on the weatherproof box (see Section 5.2 for the location of this connector).

For the 9-pin serial interface, the transmit (2), receive (3) and ground (5) pins are connected, and the others are floating.

TODO: Where does the IMU serial cable plug into?

TODO: The RS232 output of the IMU ... (serial data format)

Note, the IMU is a magnetic device and ideally should not be placed nearer than 10cm from other magnetic masses. Some calibration may be required. The sensor is best installed near the vehicle centre-of-gravity. More information can be found in "Inertial Measurement Unit: Owners Manual."

TODO: Describe the procedure for using the IMU with the ute. Particularly calibration and attitude alignment time.

4.5 Fiber Optic Gyro

Need photos. Also, see PDF docs that Juan gave me.

4.6 Compass

Need photos. Also, see PDF docs that Juan gave me.

Figure 4.5: The wheel encoder is attached to the left rear wheel-hub.

4.7 Wheel Encoder

The ROD-430 wheel encoder (see Figure 4.5) is an incremental rotary velocity encoder from Heidenhain. It operates by...

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 Notes from HSV webpage.
The encoders operate on the principle of photo electrically
scanning very fine grating with a line counts between 50 to 5000.
Shaft attaching to the wheel encoders can travel up to 12 000
rpm. Output signal for this particular model is a HTL square-wave
signal which meant that an output signals are square-wave signals
incorporating a circuit that digitizes sinusoidal scanning
signals, providing two 90 deg phase-shifted pulse trains and a
reference pulse. The encoders is power by the 12 Vdc from the
fuse box
```

TODO: - what are the characteristics of its signal? How many pulses per revolution? - what is its power source? - the data acquisition patch board provides a counter to add encoder pulses. - has two channels A and B, which permit forward and backward determination (up-down count). Draw diagram of offset pulses and how the order of the leading edge determines the rotation direction.

4.8 Velocity Encoder

The velocity encoder sensor actually comes with the vehicle; it is the standard velocity sensor used by the speedometer and odometer. The sensor is attached to the drive shaft and produces a

Figure 4.6: GPS Base Station Box.

sinusoidal signal with varying voltage and frequency. That is, the amplitude and frequency of the signal increases with increasing velocity.

A tap into this signal circuit is made ??where?? and carries the signal to the LVDT and velocity encoder board in the weatherproof box (see Section 2.5). There the signal is squared-up to produce a variable frequency square-wave of 0 to 5 volts. This signal increments a counter on the data acquisition board (see Section 2.6).

4.9 DGPS: GPS programming

This section illustrates how to program the GPS base station and the rover to work in differential mode. A Differential Global Positioning System (DGPS) is a system designed to improve the accuracy of Global Navigation Satellite Systems (GNSS). For more information about DGPS check the next link:

http://products.thalesnavigation.com/en/products/aboutgps/dgps.asp

Fig. 4.7 shows a picture of one of the GPS boxes. The rover and base GPS are exactly the same (they could be swap without problems). Fig. 4.6 shows the Base Station Box. This box contains the gps base station, the radio (see Fig. 4.9), the gps antenna (see Fig. 4.8), the radio antenna, a 12V battery and a DC-DC converter from 12V to 5V. The converter is needed because the radio is powered up with 12V and the GPS with 5V.

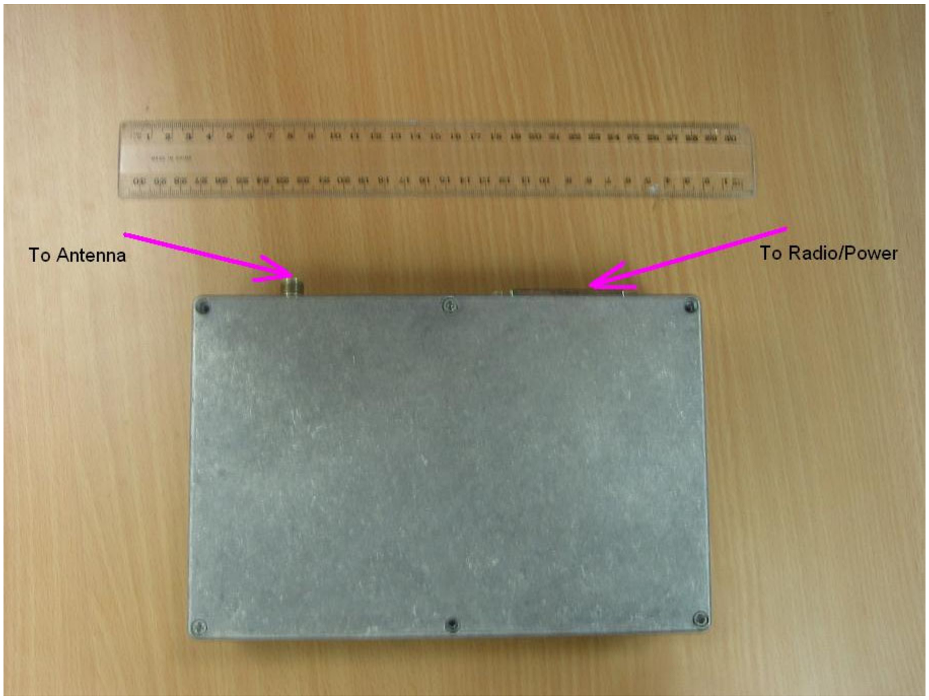

Figure 4.7: GPS sensor. The GPS board is inside the metal box.

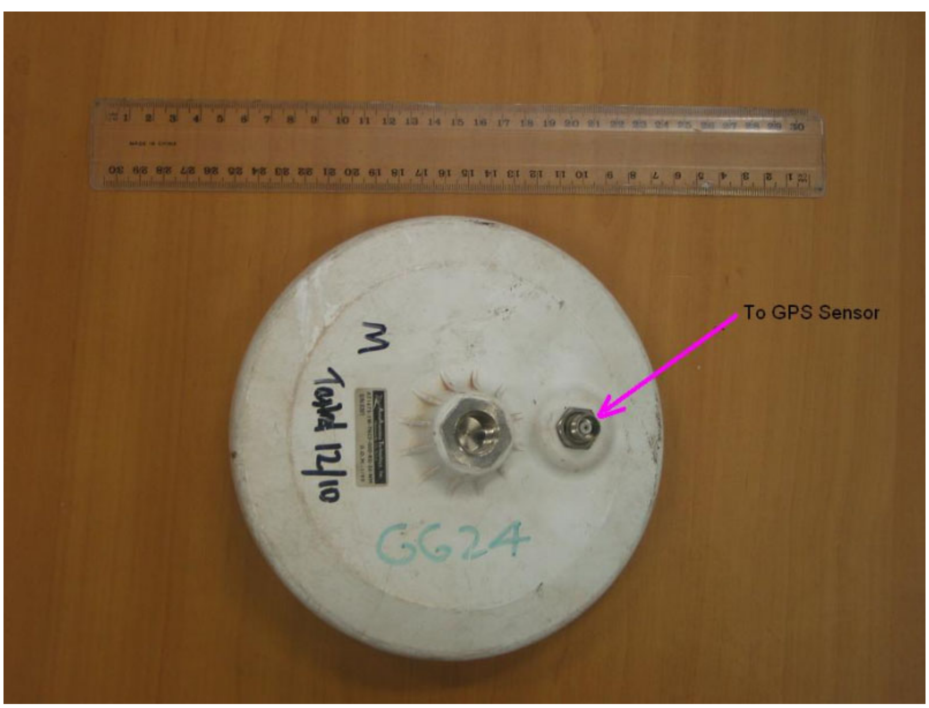

Figure 4.8: GPS antenna.

Figure 4.9: Wireless transciever.

The base and rover GPS receiver will be programmed in the different modes using script files. These files can be found in //Acfrserver/Projects/Ute/GPS/Base Station. You will need to modify only one file with the location of the base station antenna. All other files should not be modified at all. The software to program the Ashtech GPS is called "Evaluate", it comes with the sensor from the manufacturer company. The procedure is as follow:

- Base Station:

1- Connect GPS port 2 to the serial port of the computer
2- Run Evaluate
3- Connect to GPS Receiver (Press OK)
4- In the GPS menu, select Analysis (run for a reasonable duration of time), write down the latitude, longitude, and height values
These information are used to modify a line in a script file that program the unit to work as a base station and to broadcast the necessary corrections.
5- Open the file "**RTKBAS**" and change this line

$$;PASHS, POS, 3353.349561, S, 15111.651534, E, +74.00 \tag{4.1}$$

The values given in this line are position of the base station on roof of the Mechanical Engineering Department at Uni of Sydney. Remember to remove the ";" at the begining of the line. Save the file.
6- Go GPS menu and select disconnect
7- Go GPS menu again and select connect
8- Set the check box "init from file" and select the modified file "**RTKBAS**" as programming script.
Once this is done, you have the GPS working as a base station broadcasting all the messages we need for this test.
You can test the system by connecting the computer in terminal mode to the serial of the other Freewave modem. You should receive packets of information coming every second (this will come in binary format).

- Rover:

1- Connect GPS port 2 to the serial port of the computer
2- Run Evaluate
3- In the GPS menu, select "Connect using COM2" and the file "G24_DIFF". Wait for acknowledge and run again if does not initialise properly. The logging program will report state of the GPS. In this case, you will have:
0: Autonomous (not good: means lack of communication with base)
1: Differential
The system should be in differential mode, if not probably the radio is not working correctly.

Chapter 5

Connection Details Grouped According to Physical Location

This chapter describes the various connections and cables on the ute, in order of their physical locations. The aim is to facilitate identification of components, cables and connectors on the ute and tray; to enable straightforward setup of the system, both as a checklist for the experienced user and as a routing-plan for the novice. In other words, this chapter describes the physical connections required to make the ute operational. In terms of the day-to-day operation of the ute, this chapter may well be the most important reference source in this manual.

The discussion in this chapter focuses on externals—locations, connector panels, cable identification and cable paths—to document the operational configuration. Thus, a user can set up the vehicle without having to understand the particulars of the devices involved. Details of internal workings are provided in the previous chapters, and cross-references to these sections are provided where appropriate.

TODO: Need to document. Photos and diagrams of physical locations and connections. Connector types. Cable identification. Specify cable colours or IDs, screw-connection or pin numbers, etc.

TODO: Describe cable paths such as: - lasers, from serial box, to hole in left-side panel, cab via hole, under plastic skirting below passenger door, junction boxes, etc - perhaps provide a overview cable-map diagram of vehicle, showing major cable routes

5.1 QNX Box

What connections? etc

From QNX box we have laser cables etc. Describe briefly the path of these cables to their particular destinations. Many run into the ute cabin (see Figure 5.1).

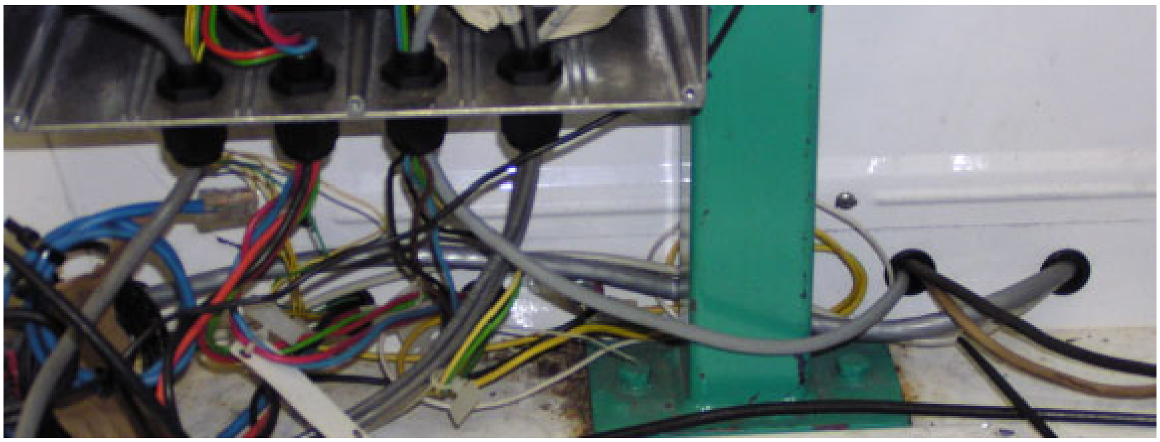

Figure 5.1: Cables run from the ute tray to the cab via these holes made in the side of the tray beneath the power amplifier box. (There are 6? holes here altogether, although some are not visible in this picture.) The cables then run beneath the tray and through a hole into the cab rear wall.

5.2 Weather Proof Box

The weatherproof box (see Figure 5.3) houses a number of significant components: the PC box (see Section 2.2), the DC-DC voltage converters (see Section 2.3), the fuse and power distribution board (see Section 2.4), the LVDT board (see Section 2.5), the data acquisition patch board (see Section 2.6), and the Ashtech GG24 GPS card (see Section 4.3). The PC box, in turn, houses the PCLabCard data acquisition boards (see Section ??) , ??video frame-grabbers?? (see Section 4.2), a PC CPU and motherboard, and various standard PC components such as video cards, keyboard inputs, and serial and parallel ports.

5.2.1 Connections to the External Panel

The external connections to the weatherproof box are shown in Figure 5.4. A schematic depicting some of these connections is shown in Figure 2.2(b). For identification, the connectors in Figure 5.4 are numbered as follows:

- 1. is the main 24VDC power coming from the ute batteries (located under the cover at the front of the tray).
- 2. ??
- 3. ??
- 4. to 7. once supplied 24V, 10A to the transputer-based ute computer and the radar sensors. These connectors are no longer required for those purposes and may be used as general-purpose 24V outlets. Note, 4. and 6. have separate fuses and so may each carry up to 10A, while 5. and 7. share a common fuse and so may carry a combined current of 10A (see Figure 2.2).

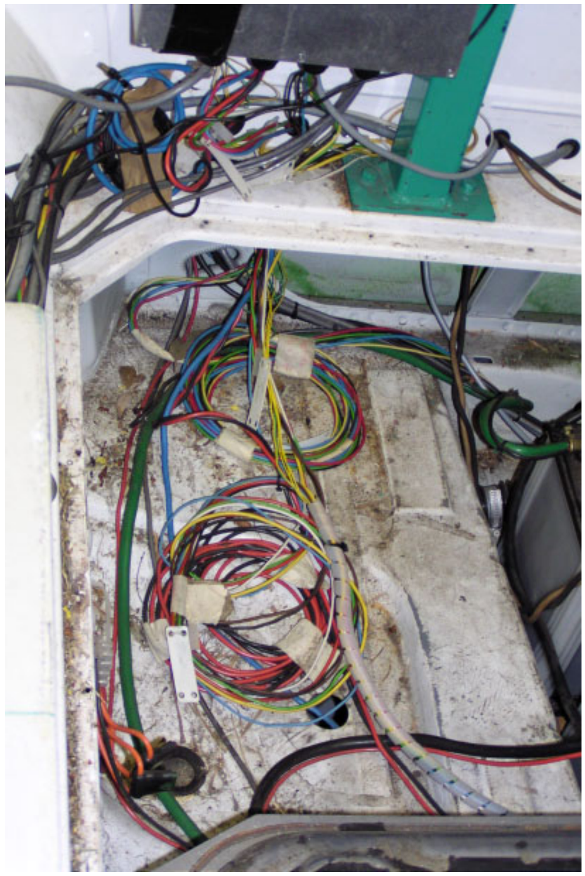

Figure 5.2: Cables run beneath the tray (accessible via cover) to the cab.

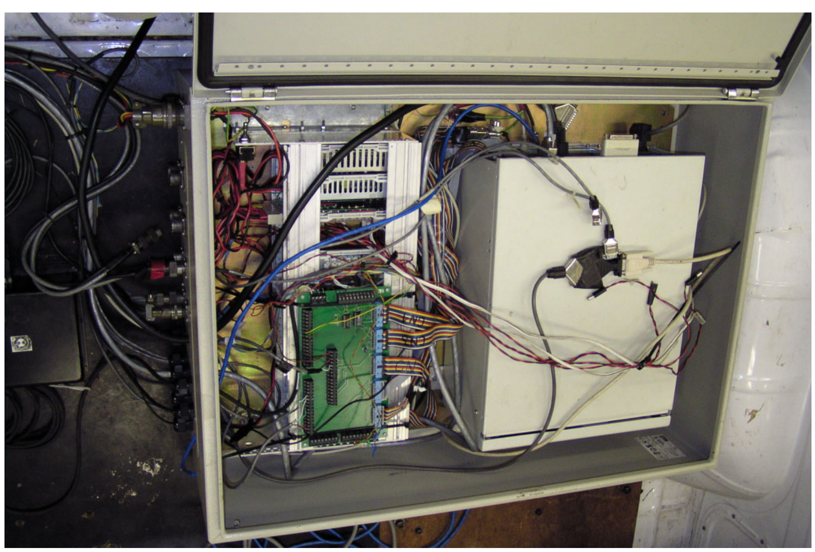

Figure 5.3: Inside the weatherproof box (located on the middle-right of the ute tray).

Figure 5.4: External connections to weatherproof box. [Need a single photo that captures entire length.]

- 8. and 9. are the cables (power and signal) to the front bumper lasers. Connector 8. goes to the left (indoor) laser, and connector 9. to the right (outdoor) laser ??check this??.
- 10. is the power source for the Watson IMU (see Section 4.4).
- 11. is the power to and signal from the steering LVDT (see Section ??). It is also the signal from the drive-shaft velocity encoder.
- 12. is the video-camera link cable.
- 13. is the PC keyboard cable for the keyboard interface in the ute cab.
- 14. is the cable for the wheel encoder located on the rear-left wheel hub (see Section 4.7).
- 15. is the monitor cable for the LCD monitor display in the ute cab.
- 16. has three cables passing through it, which are the steering, throttle, and brake control signals, and the throttle and brake potentiometer feedback signals (see Section ??).
- 17. ?? another GPS antenna perhaps ??
- 18. and 19. are not used (just holes passing thought the box).
- 20. is the ethernet cable to the PC network card.
- 21. is the Ashtech GG24 antenna cable (see Section 4.3).
- 22. is the Watson IMU serial data cable.

5.2.2 Connections to the Component Rack

What connections are to-from the component rack in the weatherproof box?

5.2.3 Connections to the PC Box

What connections are to the PC box in the weatherproof box.

5.3 INS-laser box

- juan's new serial-port junction box

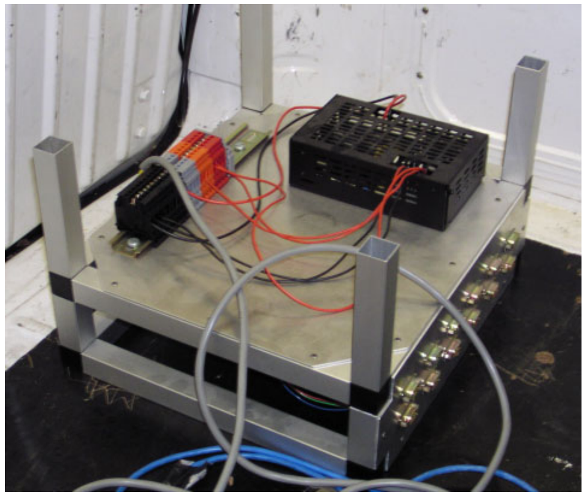

Figure 5.5: Serial connector terminal box.

5.4 Power Amplifiers

The cables from the power amplifier box pass through four holes in the bottom of the casing as shown in Figure 5.6. These cables can be identified as follows.

- Hole one has one thick gray cable, four yellow wires and a green wire. The gray cable is power (24VDC) from ??where?? on the weatherproof box. This connects to the white terminal block in the top-left of the amp-box (see Figures 2.5 and 2.6 in Section 2.8), where pins 1,3,5,7 are 24V and pins 2,4,6,8 are power ground.

  The four yellow wires and the green wire are from the manual override switch-pad in the cab (see Sect ??). The yellow wires are the parallel returns of the normally-open switch and they converge at pin 1 on the circuit board connector (see Figure 2.7). The green wire goes to pin 16 on the circuit board connector.

- Hole two has six wires—three pairs loosely twisted. These are the power cables from the three amplifiers to the three actuators. The red-black wires go to the steering motor, the red-green wires to the brake motor, and the red-blue wires to the throttle motor. From the amp-box, these cables pass though a hole in the side of the ute tray to the actuators located in the cab.

- Hole three has seven cables—two sets of three and a thick gray cable. Each of the two sets of three are clipped together with a labeled cable-tie between the amp box and where they pass through a hole in the side of the ute tray. These wires are the plus-minus reference voltages and return signals for the throttle and brake potentiometers. The yellow-green-black wires go to the throttle potentiometer, and the blue-brown-black wires go to the brake potentiometer.

  The gray cable also passes through a hole in the ute tray (to the cab). It contains two black wires that connect to 24V and GND in the amp box, and goes to ??.

- Hole four has three gray cables going to the weatherproof box to the PC data acquisition board. One cable has the analog control signals for the throttle and brake actuators. One has the analog control signal for the steering actuator. And the third has the position feedback signals from the throttle and brake potentiometers. (See Section 2.6 for the exact destinations of these cables.)

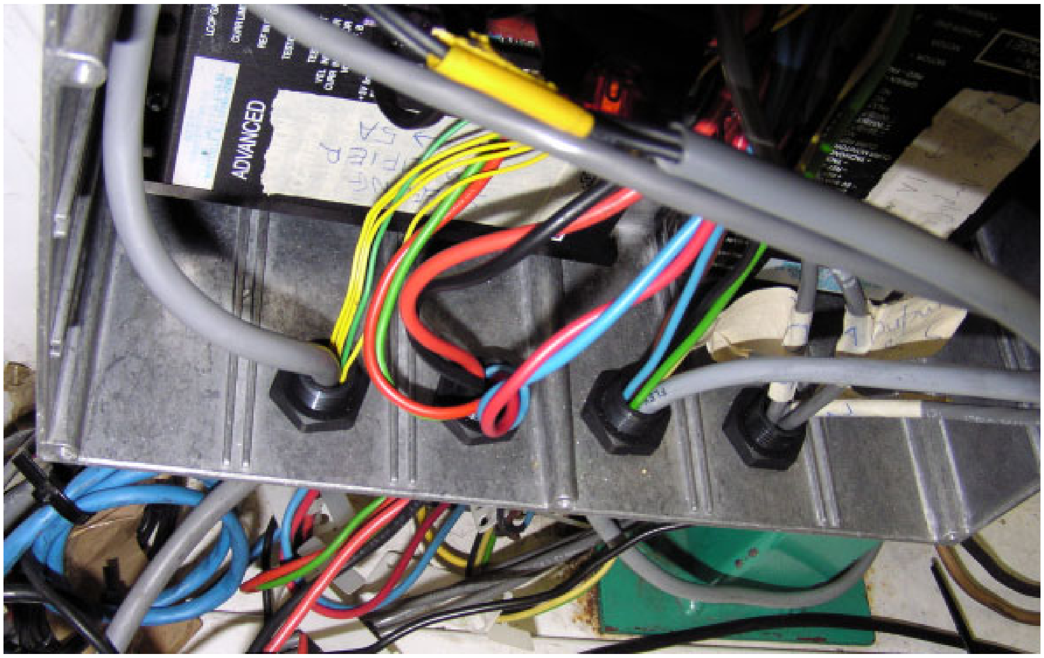

Figure 5.6: Cables from the power amplifier box.

5.5 Cab—Driver's Side

On the driver's side of the ute cabin there is the following equipment. Under the driver's seat is the brake actuator. To the left of the brake peddle, directly below the steering column, is the steering actuator (see Figure 5.7). Taped to the brake peddle is the manual override pad.

TODO: Brake actuator and potentiometer. N wires, colours, to-from... etc

TODO: Steer actuator. Red and black wires (power), to-from. What is the third cable going to the steer motor (see Figure 5.7)?

TODO: Manual override pad. ribbon cable, to-from

5.6 Cab—Passenger's Side

Under the passenger's seat is the throttle actuator, which controls a cable connected to the engine throttle. To the left of the seat, beneath the door, runs the cabling for the front bumper lasers (and ?? what else). The laser cables come from a hole in the cab rear wall and run under the plastic guard next to the door frame. These cables meet junction boxes on the front-left of the passenger's floor.

TODO: Throttle actuator.

TODO: Laser cable junction boxes. Junction box 1 is attached to the cab wall at the front-bottom-left of the passenger's side. The second box is unattached lying on the floor.

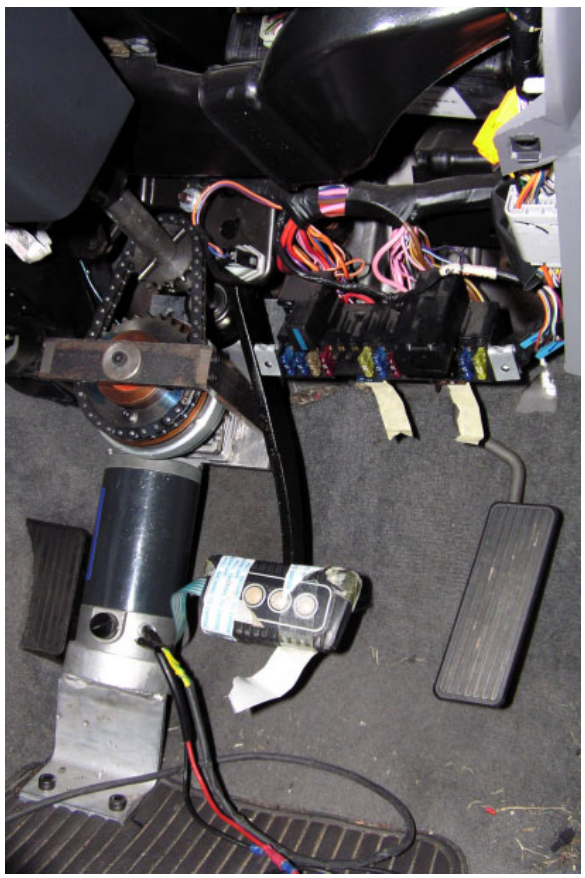

Figure 5.7: Inside cab, driver's side. View steering actuator and manual override pad taped to brake pedal.

TODO: What is the other mysterious box near the laser junction boxes?

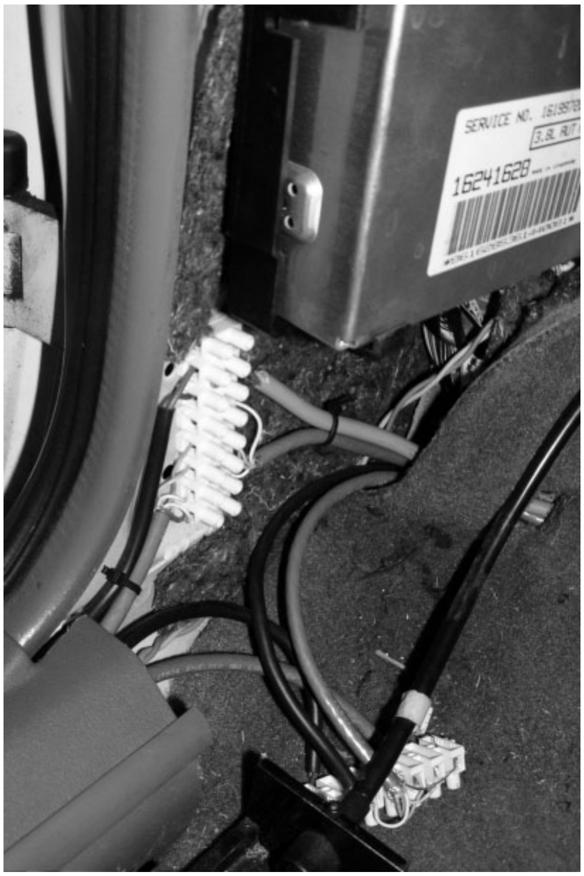

Figure 5.8: Inside cab, passenger's side. View laser cables, which are run beneath plastic liner below door, laser cable junction boxes, throttle actuator, ...?