Vehicle Robot

Introduction: The CP Engineering Systems Ltd., Vehicle Robot consists of a number of sub-assemblies that are light enough to be assembled by one person into a vehicle, connected together, *taught* and transferred to the chassis dynamometer in minimal time.

The Vehicle Robot can be supplied as a stand-alone system or integrated into the CP Vehicle Test system.

General Description

The Vehicle Robot sub-assemblies include:

- Torso shift module. X-axis gear shift position
- Torso select module. Y-axis gear select position
- Pedal Box. Throttle, clutch and optionally brake actuation
- Electronic Control Unit. Power supply for the Torso and Pedal Box
- CP128 Control and Monitoring System (I/O)
- Standard Pentium computer

DC actuators and mechanical linkages are part of the Torso and Pedal Box and powered by the stand alone 110 Volts AC Electronic Control Unit. A standard PC controls the power circuitry through the CP128 Control and Monitoring rack. The CP128 rack and computer may be a stand-alone Robot Control, or part of an integral CADET chassis dynamometer system.

To minimise gearbox wear and to assist in gear training, magnetic clutches are used to de-couple the gearshift arms from the drive actuators. By employing this method, minimum wear on the selector forks and hubs within the gearbox is achieved. The overall design is suitable for the inclusion of force sensing at the gear lever by the inclusion of in-line load cells in the actuator struts.

The software only engages the magnetic clutches when a gearshift is taking place to ensure that the forces acting on the gearshift during normal operation may be ignored. A further benefit of the clutches is their guaranteed maximum force transfer that protects the transmission in fault conditions.

Installation into the Vehicle

The two Torso modules that slot into each other in the vehicle, and the Pedal Box, can be installed on the same side of the vehicle or on different sides of the vehicle. The Electronic Control Unit would usually sit on the rear seat. If the Torso and Pedal Box are installed on opposite sides of the vehicle a number of benefits result.

- The vehicle can be driven to and from a rigging area fully prepared to run thus minimising preparation time on the Chassis Rolls.
- Training of the gears is easier as the operator may sit in the driver's seat to *feel* the shift.

This modular construction of the system also allows a variety of control options that make the Vehicle Robot suitable for use with existing rolls controllers for either emissions, or durability testing.

The Torso may be attached to the vehicle by rigid brackets, or can be used without such fixtures when strapped into one of the vehicle front seats. An additional option of expansion struts that can be fixed to at one end and expanded against the door pillars or screen surround may be used where seat design makes location by strap difficult.

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The Design Approach

The Torso module is split into two sections that are locked together in use. These contain the Shift (left-right X-axis) and the Select (front-back Y-axis) modules. One person may split the torso to enable installation of the robot.

The Torso gear selector module has been designed around the general envelope of a human driver to allow it to be used in the majority of vehicles.

The performance of the system is commensurate with typical driver operation with a total gear-gear time of less than one second supported by the standard actuators. As an option special high performance actuators are available.

Adjustment of the X-axis shift actuator mechanism relative to the seat is provided to allow the maximum length of strut to be used in vehicles of both right hand and left hand drive. Overall positioning may use the seat while actuation struts, with low friction ball joints, are expandable in steps of 25 mm using press release keys.

The Y-axis shift module gear change arm may be mounted on either end of the actuator shaft that allows rapid set-up for either right-hand or left-hand drive vehicles. It is possible to convert from left-hand drive to right-hand drive configuration in less than two minutes.

The pedal box module provides three actuation struts for clutch, throttle and optional brake. The struts are expandable in steps of 25 mm using press release keys and are fitted with ball joints at each end. A clamp bracket with integral ball end is fixed to the pedal to allow the strut to be clicked into place. The pedal box module is fixed to the vehicle by brackets clamped to the seat sub-frame. Alternatively, fixtures are provided in the pedal box module to accept the torso module fixings when they are both installed in the driving seat.

The electronic control unit contains all the necessary power electronics to drive the Vehicle Robot. Line supply is via an IEC connector and three multi-pole connectors allow interfacing to:

- The Select/Shift Torso
- The Pedal Box
- The CP128 Control and Monitoring System

A number of LED displays on the unit indicate the state of the drive and clutch control signals, and a precision 5 Volts position potentiometer excitation supply is included.

The Torso shift and select drivers are controlled by open loop driver circuits with H bridge drive capable of accepting an external ‘drive demand’ set point. Current limit protection is included with a pre-set characteristic to protect the actuators.

The Pedal Box throttle, clutch and optional brake drivers are controlled by closed loop driver circuits with H bridge drive capable of accepting an external position set point and input position data from a precision position potentiometer or a direct input voltage. Feedback of position to the external controller is available.

Current limit protection is included with a pre-set characteristic to protect the actuators.

The computer control software and CP128 Control and Monitoring System are capable of controlling the Vehicle Robot as a stand-alone system. The software includes a programmable auto-shift facility, safety limits and the ability to follow a pre-programmed test schedule from an internally stored data file. Miss-shift recovery routines and manual and automatic training routines ensure reliable operation.

When used in conjunction with the standard CP Engineering Chassis Dynamometer Test System, that includes inertia simulation to meet the EPA requirements, road load and coast down features, the Vehicle Robot software would be integrated onto the dynamometer test system control computer.

Configuring the Vehicle Robot

The strategy used by the Vehicle Robot during gearshifts is set within the program but it is fully configurable. This allows the optimum settings of change times and forces to be determined and stored along with calibration data for the rolls speed and engine speed. A full safety and automatic gear map may also be stored. Gear ratios are stored to assist in detecting a miss-shift. These ratios may be determined from a technical manual or by operating the vehicle manually on the rolls.

Once these settings have been stored they may be re-called and the system is ready for use once training has been carried out.

Training the Vehicle Robot

The Vehicle Robot is trained in a number of steps to perform gearshifts. This is achieved by the use of a keyboard and monitor positioned locally to, or within, the vehicle. It is generally necessary to carry out this training on each occasion that the Vehicle Robot is installed in a vehicle.

The X-Y positions of the centre point of each gear position are taught to the system. This process is very fast making it possible to quickly re-train the system if the position of the Vehicle Robot is changed.

The throttle is automatically mapped to determine the required throttle positions during the gear changes. This is achieved under the control of the software with the engine running. A signal is required which represents the engine RPM.

Both the clutch, and when applicable the brake, bite-points are taught to the system by the press of a single key as it is determined manually.

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Specification

Torso Both Shift and Select modules use the same actuator systems.

Torque (In-shift)		**10 Nm**
Reduction Gear ratio		**4.167:1**
Material		**Delrin**
Arm Length		**350 mm. Shorter arms, for more force, are available**
Clutch Limit		**6 Nm**
Lever Force (at max speed)		**60 N (Clutch protected at max speed)**
Movement		**250 mm**
Traverse Time		**220 ms - Off-load**
Materials	Unit	**Stainless Steel and Aluminium (Hard Anodised)**
	Cover	**Aluminium Powder finish**
Weight	Torso shift module	**10 kg**
	Torso select module	**9 kg**

Pedal Box The pedal box contains throttle and clutch (brake as an option) actuators mounted on a single 30mm diameter stainless steel shaft. The shaft may be mounted to the torso or the vehicle seat in a number of configurations.

Width (minimum)		**250 mm (throttle and clutch)**
Height		**190 mm**
Depth		**190 mm**
Weight		**6 kg (throttle and clutch)**
Electrical Connections		**1-off 19 pin connector**
Materials		**Stainless Steel and Aluminium (Hard Anodised)**
Torque (In-shift)		**10 Nm**
Reduction Gear ratio		**3:1**
Material		**Delrin**
Lever radius positions		**90 mm, 115 mm and 140 mm**
Max Force		**250 Nm**
Movement		**250 mm max**
Time	Clutch	**350 ms Typical**
	Throttle	**250 ms Typical**

Electronic Control Unit

Width		**520 mm**
Height		**160 mm**
Depth		**400 mm**
Weight		**17 kg**
Line Power Supply.		**110 Volts AC, 50 – 60 Hz**
Power supply	Voltage	**60 Volts DC Nominal**
Power		**1 kW Type in-shift capacity**
Output Circuits		**H Bridge - Switched Mode 20 Amps Capacity**
Input Circuits		**±5 Volts, or 0 - 5 Volts**
Hardwired Shutdown Circuits		**Clutch Down/Throttle Closed/Gear Unloaded**

06/1999

CP Engineering Systems Ltd.
Tel: +44 (0) 1684 584 850 Fax: +44 (0) 1684 573 088 Email: sales@cpengineering.com