

Design compliance of modifications made to 1999 Toyota Echo 2-door hatch, registration number 828HUV (VIN JTDJW133200010642) for conversion to electric drive.

The following document details the modifications made to 1999 Toyota Echo 2-door hatch, registration number 828HUV (VIN JTDJW133200010642) for conversion to electric drive with specific numbered point reference to the guide "Design Requirements for Conversion of Motor Vehicles to Electric Drive in Queensland" written by Ron Penfold.

1. Compliance With Design Rules

The vehicle remains compliant with all the Australian Design Rules that the vehicle was designed and built to meet in 1999.

2. Battery Installation.

2.1(a) Battery Restraint – Engine compartment batteries;

There are 5 x 24kg lead acid batteries in the engine compartment, which are mounted on a galvanised iron frame. Each battery is held to the frame with 2 polypropylene straps rated at 280kg each, which is equivalent to a crash deceleration rating of 23G.

The galvanised iron frame is anchored to the chassis with 5 x M10 and 4 x M8 grade 8.8 high tensile bolts. The manufacturer of these bolts specifies a single shear rating (across the threads) of 26kN (M10) and 16kN (M8). This equates to 2,650kg and 1,630kg respectively at 1G. This gives a total anchoring capacity of 19,770kg. The 20G mass of the batteries and frame is $((5 \times 24\text{kg}) + 15\text{kg}) \times 20 = 2700\text{kg}$. Therefore the 20G requirement is surpassed by a multiple of 7.

2.1(b) Battery Restraint – Rear battery rack;

Similarly there are another 5 x 24kg lead acid batteries in a galvanised iron frame at the rear of the vehicle. A 12mm MS rod anchored in 4 positions holds down the batteries in this rack.

The frame is anchored to the two rear chassis cross members with 8 x M10 grade 8.8 high tensile bolts. Total shear strength = 21,200kg. 20G mass of batteries and frame = 2700kg. Therefore the 20G rating is also surpassed by a multiple of 7.

2.2 Both battery racks are mounted externally to the body shell with no permanent openings between the batteries and the interior of the vehicle.

2.3 Both battery racks are made from 4mm galvanised steel. The rear rack has 1.5mm aluminium sheeting on all sides (to protect the batteries from debris).

2.4 Not applicable.

2.5 Not applicable.

2.6 Not applicable.

3. Venting of Battery Compartment

3.1 – 3.3

Both battery racks are not enclosed and consequently, by design, are directly vented to the atmosphere; therefore this section is not applicable.

4. Power System

The electrical propulsion circuit is completely isolated from the original 12VDC vehicle electrical system. All propulsion cabling is, at minimum,

double insulated from the body earth, and where exposed to chafing or abrasions, is also encased in rigid conduit. The exterior of the propulsion controller and motor, whilst both metallic, are electrically isolated internally. The propulsion circuit contactor, disconnect switch, fuse, relays and interconnects are all mounted inside ABS electrical enclosures with a minimum protection rating of IP64.

Apart from the petrol motor wiring, the original 12VDC system is intact, including the alternator, which is mechanically driven (and therefore electrically isolated) by the electric propulsion motor.

5. Controls

The master isolation switch is constructed so that the switching contacts are sealed from water ingress and therefore is spark suppressive. In addition to this the master isolation switch assembly is mounted in an IP64 enclosure which is designed to stop foreign materials entering the enclosure from any direction.

The original ignition key operates the electrical propulsion circuit master switch. This is a normally open switch so should the 12VDC system fail, the master-operating contactor will open circuit. There is also a prominent manual disconnect stop for the electrical propulsion circuit mounted forward in the engine compartment. (Also the driver can remotely open the filler cap door which will open circuit the main contactor by design, see paragraph 8.5.)

6. Electrical Installation Standards

- 6.1 The propulsion circuit contactor, disconnect switch, fuse, relays and interconnects are all mounted inside ABS electrical enclosures with a minimum protection rating of IP64. The propulsion motor and controller are splash protected by under-car moulded plastic guards.
- 6.2 There are no components or wiring of the electric propulsion system within the passenger compartment, apart from where used for instrumentation, in which case incorporates very low-current safety fuses.
- 6.3 All cable used for the traction circuit is double insulated (Nitrile/V90HT PVC) and meets or exceeds AS5000.1 - AS1995 standards and is capable of 560amp at 30% duty cycle. It is 70mm² and is classified as "welding" cable.
- 6.4 All wiring is secured to the body/chassis at no more than 600mm intervals and where exposed to chafing or abrasion is protected by at least one layer of rigid conduit.
- 6.5 Any failure of the variable control circuit (accelerator) results in controller shutdown. Any failure in the propulsion circuitry results in open circuit of the main contactor, which disconnects all power from the controller and motor.
- 6.6 The traction circuit fuse is mounted inside the switching enclosure adjacent to the front battery rack.
- 6.7 The main traction circuit fuse is rated at 500A DC.

7. Other Considerations

- 7.1 A Toyota Australia provided the following weight specifications for Toyota Echo 3 door hatchback;

	Rear	Front	Combined
Curb	420kg	530kg	= 950kg

GVM 700kg 675kg = 1375kg

Calculated new curb weights are;

	Rear	Front	Combined
Curb	420 + 160 ⁽¹⁾ = 580kg	530 + 80 ⁽²⁾ = 610kg	= 1190kg

Calculated new maximum laden weights (as a 2 seater);

	Rear	Front	Combined
Max	580 + 107 ⁽³⁾ = 687kg	610 + 57 ⁽³⁾ = 667kg	= 1354kg

(1). Calculated additional weight over the rear axles due to the battery pack, battery rack and battery support bracket assembly.

(2). Calculated additional weight over the front axles due to the battery pack and rack, minus the difference in weight between the petrol motor and electric motor.

(3). These weights are calculated as follows: All luggage (28kg) is over the rear wheels. Due to the rearward position of the front seats in this 2-door vehicle (with respect to a wheelbase of 2.4mtrs) the passenger weight is offset towards rear of vehicle by a ratio of 1.4:1. Therefore the total passenger weight of 136kg is divided into 79kg (rear) and 57kg (front).

- 7.2 The original vacuum assisted brakes are designed to operate at a vacuum of between -13”hg and -18”hg. This requirement has been met with the installation of a 12VDC electric vacuum pump (the model fitted is used extensively in electric vehicle conversions) and vacuum switch which is set to operate at -18”hg. As an added precaution the vacuum system has an added reservoir tank of 2.5ltrs capacity.
- 7.3 No alterations were made to the sub frames, chassis, cross or body members in the fitting of the electric motor. All three of the existing engine / transmission mounting points were maintained and not modified. The steering mechanism was not modified and is not of the power-assisted type.
- 7.4 4mm mild steel was used for motor mounting bracket. This bracket attaches to the original engine mount using the original single M10 grade 8.8 bolt and incorporates the original safety cage mechanism should this bolt shear in a collision, as designed.
- 7.5 All access holes to the vehicle cabin remained sealed as original, apart from the cabin heater water pipe entrances, which have been sealed appropriately.
- 7.6 No modification was made to the speedometer sender unit as it is mounted in the transmission drive shaft housing.
- 7.8 The original heated-water demister element was replaced with a 12VDC 250W ceramic heating element.

8. Points To Remember

- 8.1 The switching control enclosure is labelled “DANGER, HIGH VOLTAGES INSIDE”. There is no exposed high voltage conductive material that has access without the removal of protective covers and/or insulation.
- 8.2 No audible reversing alarm is fitted. However the controller produces a 1500Hz square wave at low speeds, which is transduced by the electric motor into a very audible “squeal” in either forward or reverse.
- 8.3 All components are designed and manufactured to operate within the temperature ranges suggested of -10C to +50C.

- 8.4 Only simple metal fuse used.
- 8.5 The access door for the charging socket (original "fuel flap") is fitted with a door switch and relay which acts as a safety interlock to disable (open circuit) the main contactor while the door is ajar.
- 8.6 The vehicle retains the original transmission and does not have an electric reversing circuit

9. Special Notes

- 9.1 Considered unnecessary as the vehicle uses a battery charger designed for a standard 240V 10A GPO.
- 9.2 To the best of my knowledge the vehicle wiring meets or exceeds the AS 3000:2000 wiring standards.

This document written by,

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