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The Development of a Mobile EV Charge Solution to support the EV Driver and delivered by the Global Automotive Clubs

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Abstract

The rapid deployment of Electric Vehicles Globally has led to a special need for a sophisticated Mobile EVSE Solution to enable the Automotive Clubs to offer that extra roadside service to the EV driving Membership to assist to offset any range anxiety and also to underpin the effective use of Electric Vehicles.

The most recent development by Club Assist of a small Mobile EV Charge trailer that can be towed behind a motorcycle or small rescue van adds real value to the Motoring Associations as well as Government, by providing a dynamic service that can be delivered via use of the Emergency traffic lanes on Toll ways, Freeways, and traffic tunnels, thus helping to avoid substantial traffic delays in a real world.

Club Assist has developed and is already in production of two versions of ICE powered Mobile EV Charge trailers – one a conventional gasoline powered and another version designed to run on "emission clean" Liquid Petroleum Gas (LPG), or Propane as the petroleum by-product is known in North America.

In addition Club Assist Product and Technical Development department is finalising a development of a fully Lithium-ion powered Mobile EV Charger – Level 2, which is seen as the ultimate in use of EV concepts in a new Rescue service environment. This variant of the Mobile EV Charger generates no roadside emissions, is totally quiet in operation, odourless and is designed to perform two rescues in a daily shift before return to base for re-charge.

Keywords: Mobile, EV Charger, Lithium-ion, Propane, Level 2

1 Introduction

The Mobile Level 1 and Level 2 Electric Vehicle (EV) charger is designed to allow convenient access to an EV that has a fully depleted high voltage traction battery and is disabled at roadside or in a location where there is no fixed site EV charge facility.
The trailer is deliberately compact in size and is designed for towing behind a small vehicle –

maybe an EV – or a Motorcycle, thus delivering improved access to a broken down EV due to manoeuvrability in dense traffic areas.
The ICE powered Mobile EV Charger is equipped with two EV Charge facilities as follows:

- **Level 1** – 240 volt AC and 15 amp maximum. Designed for those EV's that can only take the 15 amp rating. A similar version of Level 1 is also an option – 120Volt at 10amp.

- **Level 2** – 240 volt AC and 30 amps - 6.6Kw -nominal. Designed for EV's that are fully enabled to international SAE J1772 [1] Level 2 capability.

The Mobile Charger connectivity for Level 2 is the SAE J1772 [1] connector, which in Level 2 allows Control Pilot signal and Proximity signal operations. This connectivity will allow SAE J 1772 compliant vehicles including Battery Electric Vehicles, and plug-in hybrid vehicles (PHEV's) to communicate and be charged. SAE J1772 is an electric vehicles charging standard that has been developed by the Society of Automotive Engineers (SAE) [1], the governing body of Automotive Standards in North America, Australasia and Europe.
Instrumentation is built into the Mobile Charge Control Computer to enable the field operator to constantly monitor the electrical delivery and performance of the Mobile EVSE.
Over 14 Mobile EV Charge trailers with these optional configurations have so far been ordered or delivered to the Club Assist Partner Automotive Clubs.
Future Mobile EV development is already underway, with the deletion of the ICE and replacement with a Lithium-ion battery pack, equipped with its own BMS and re-charge facility. This absolutely "Green" version of the Mobile EV Charge Solution will compliment and completely support the principles of the EV industry.
Additional work is also being done by Club Assist Research and Development to design and build a Proof of Concept Mobile DC Fast Charger that can also be CHAdeMO compliant.
The Paper outlines the steps achieved with the development of the Mobile EV Charge facility and takes the reader through the engineering aspects of the development.

1.1 Scope of Development

Starting from a clean sheet the design parameters of the "Proof of Concept" mobile EV Charger was:

- A need for Level 2 EV Charge protocol delivery – code 2 & 3 in accordance with SAE J1772 standard.
- Compact and easily manoeuvred into difficult to access EV locations
- Relatively quiet in operation.
- Lowest possible emissions.
- Simple to operate.
- Simple to access for servicing.
- Quality EV Charge control computer – ruggedised in construction.
- Need to be able to utilise "noisy" and average sine wave forms due to ICE using poor quality fuels.
- Combined safety features to protect operators and EV on charge.
- Long service life – robust construction.
- Available in trailer or skid mounted versions.

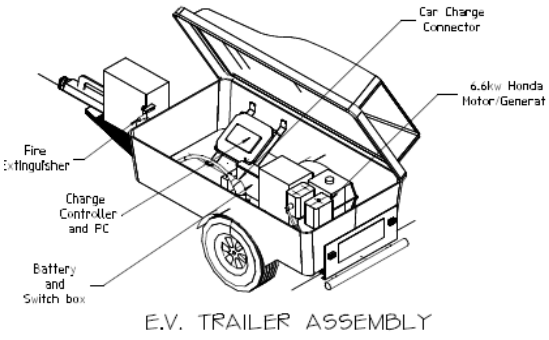
1.1.1 The Trailer

Club Assist searched the available Australian trailer manufacturers that had a high quality reputation, in the trailer build business for many years and had a good design that met with the requirements of a load carrying use.

The trailer basic design criteria were:

- Robust hi tensile steel chassis fully powder coated for weather protection.
- No free entries to any chassis rail or tube to avoid salt capture in ice prevention climates.
- Hydraulic disc brakes, stainless lines.
- Independent rubber based trailing arm suspension to avoid road shocks transmitted to EV Charge computer.
- Glass reinforced plastic body, lockable and weather proof.
- LED lighting in accordance with road traffic acts in all Global Regions.
- 50mm tow ball hitch – optional $1^{7/8}$ inch ball hitch for North America.
- Can be built in RHD and LHD versions – to avoid operator standing on traffic lane areas.

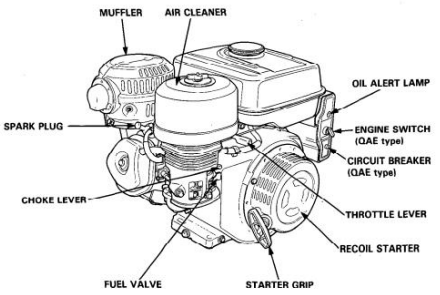
- Body to be able to accept any branding image in cut vinyl graphics.



E.V. TRAILER ASSEMBLY

1.2 The ICE Selection

The ICE selected is from the Honda industrial engine range – with Euro 2 emissions rating. The engine is an 11Hp model with a 2.5 litre fuel tank and electric starter. Additional exhaust routing has been incorporated. A compact and globally serviceable internal combustion engine.



SPECIFICATIONS—ALL AIR CLEANER TYPES

Engine type	4-stroke, overhead valve, single cylinder	
Displacement (Bore x Stroke)	242 cc (14.8 cu in) (73 x 58 mm (2.9 x 2.3 in))	337 cc (20.6 cu in) (82 x 64 mm (3.2 x 2.5 in))
Max. output	8.0 HP/3,600 rpm	11.0 HP/3,600 rpm
Max. torque	1.7 kg-m (12.29 ft-lb)/2,500 rpm	2.4 kg-m (17.36 ft-lb)/2,500 rpm
Fuel consumption	230 g/HPh (0.7 lb/HPh)	
Cooling system	Forced air	
Ignition system	Transistorized magneto	C.D.I. with electronic advancer
PTO shaft rotation	Counterclockwise	

NOTE: Specifications are subject to change without notice.

1.3 The Alternator

This unit comes from NSM generators in Italy and is a well designed and assembled unit with two poles thus delivering 240 volts; 50 Hz cycles @3000rpm when wired to the Multiple Earth Neutral MEN configuration. Twin cooling fans are incorporated, which also deliver the air flow for the engine cooling. The alternator can be run at 3600rpm to deliver 240 volts and 60Hz.

Image showing typical wave forms from alternator outputs.

1.4 The EV Charge Controller

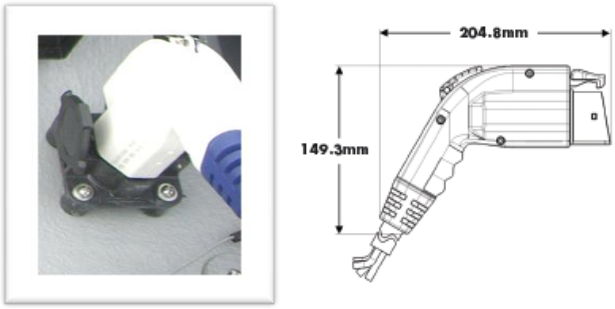
This computer is a ruggedised version of an AeroVironment typical wall mounted EVSE. There is no need for networking as this is a mobile emergency rescue service EV Charger. An hour meter and Hz frequency gauges are installed on the controller face.

The Controller communicates with the EV under charge to determine the charge requirements.

1.5 Delivery cable and Connector

As the mobile EV Charger is fully compliant with SAE J1772 standard the delivery cable has an active, neutral and ground for the 240 volt AC feed along with a Control Pilot signal connection and a proximity connection making 4 cables and terminations within the delivery cable assembly. The delivery cable is "hard wired" to the EV Charge Control Computer.

The connector handle is fully SAE J1772 compliant with an integrated micro switch to enable a Prox signal to be sent to the Control Computer.
Security of the connector when not in use is gained by the fitment of a SAE J1772 holster assembly, located on the floor of the trailer body.



2. Assembly of the Major Components

All the major components – ICE, alternator unit, Charge control computer, auxiliary battery, cable holster and safety fixtures such as fire extinguisher, gloves, wheel chocks and safety glasses / ear plugs are located in defined areas within the internal trailer body. The extra fuel supply is stored in a approved design 10 litre portable fuel can located on the draw bar area.

3. Testing and Commissioning

The trailer, once assembled, is run up through a varying load bank and after some 30 minutes of operation the frequency (Hz) of the alternator is validated with a digital oscilloscope and the entire load rating recordings is made. Exhaust temperatures are monitored and recorded. In addition a Sound Pressure wave (decibels – Db) recording is taken to ensure full compliance with various Ministry Directives.

4. Next Generation Development

Following on from the success of the first ICE powered mobile EV charger we have now completed a Propane (LPG) version as an optional improved emissions unit. This trailer incorporates a Liquid Gas (Propane) delivery system to a converter and pressure regulator located close to the existing carburettor.
Performance of the Propane charger is equal to the petroleum fuelled charger, still capable to deliver 6.6Kw of charge energy.

Image of LPG unit

5. Lithium-ion Powered version

This is the current development project and the following brief specifications are relevant

- Battery System – 16- LiFePO4 cells delivering 51.2 volts. 9.216KWh storage energy. Connected in series.
- Inverter – 48 V pure sine wave output AC220-240V. Continuous output power – 8000W
- On Board Charger – 85-265VAC inputs, 45Hz-65Hz, Max DC output 66V. Max output current – 140A
- Cassette – contains 8 cells in each row and two rows together. Forced air flow.
- Battery Management System – 12V inner CAN, whole car CAN1, charging CAN2
- EV Charge controller - Level 2, modes 2-4, fully SAE J1772 compliant. Incorporates Control Pilot Signal (CPS) generation and Proximity Signal communication.

The work in progress images are as follows:

Image of LiFePO4 battery cassette

Image of HV battery charger

Image of BMS, connectors, fuses etc

6. Performance Specifications

The following table summarises the performance and specifications for the Mobile EV Charge trailer, powered by ICE or Lithium-ion HV battery Pack.

Table1: Performance levels for charging (240V)

	Specification	
Output Voltage	240 V AC	
Output current	32A	
Output power	6.6Kw	
Frequency Options	50Hz-60Hz	
Communications	Cont. Pilot Signal	Proximity signal
Run Duration	To 45 min - ERA	2.5Hrs continuous
Cooling	Forced air	Twin fans

Glossary

AC – Alternating Current
CAN – Controlled Area Network
DC – Direct Current
A – Amperage - Amps
EV – Electric Vehicle
ERA – Emergency Roadside Assistance
EVSE – Electric Vehicle Supply Equipment
HV – High Voltage
ICE – Internal Combustion Engine
SAE – Society of Automotive Engineers
CP – Control Pilot Signal
LPG – Liquid Petroleum Gas (Propane and Butane)
LiFePO4 – Lithium Iron Phosphate

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References

[1] Society of Automotive Engineers – International for licence for use of SAE J1772 Standard.

Author:

Robert Gell is a member of a small but highly focussed Research and Development Team at Club Assist, the Global Motoring Service Providers to the Automotive Clubs in three continents. Club Assist has a responsibility for support for the Auto Clubs in the area of development and launch of a Mobile EV Charge Solution so that the Auto Clubs can deliver roadside services to the EV Club Members drivers. Robert is an Associate Member of the Society of Automotive Engineers (SAE-A) and a Member of the Institute of Automotive Mechanical Engineers – IAME.