After driving an EV1 for 5 years I was hooked on the electric vehicle mode of transportation so I decided to build my own.

Body:

I wanted a comfortable car with adequate room to install the batteries and drive train. I found that the Toyota Corolla fit the bill nicely. The conversion to electric required that the car come equipped with a manual transmission. Fortunately, I found a vehicle that was in really good shape, had power accessories, air bags and a manual transmission.

The suspension was modified by Streetwise (http://www.streetwiseparts.com) to accommodate the extra weight of the batteries. The height of the car is adjustable and the springs are replaceable allowing adjustment of the ride and handling.

The tires are Bridgestone B381 with low rolling resistance.

Drive Train:

The motor is a three-phase AC motor and the inverter converts the batteries' DC power to three-phase AC. I decided to go with an AC drive train mainly due to my experience with the EV1 which also had an AC drive train. I liked the availability of regenerative braking and the higher voltage allowed for the use of smaller gauge wire, which was easier to work with.

The Siemens motor and inverter were purchased from Metricmind Corporation (http://www.metricmind.com). They are a matched pair and the inverter software is programmed to operate and monitor the motor precisely. The inverter is fully programmable allowing the operator to match the inverter to the specifications of the battery pack and adjust the driving & braking characteristics. The inverter is accessed via a laptop computer. The laptop can also be used to view real-time data while the vehicle is operated.

The inverter includes a 60 amp 12V accessory inverter for operating the car's electrical system and charging the 12V accessory battery.

The motor and inverter are water-cooled. A small circulating pump runs water through a small radiator, the inverter and the motor. The inverter monitors the temperature of the inverter's drive electronics heat sink and the motor core. The inverter will engage a cooling fan on the radiator if any of the temperatures exceed a programmable set point. The inverter will also lower the available power to the motor if the motor temperature exceeds a factory preset value – preventing any damage to the system.

The motor is connected to the transmission housing via a custom adapter plate fabricated by Electro Automotive (http://www.electroauto.com). The clutch is removed and the motor shaft is directly coupled to the transmission input shaft, saving weight. The gears can still be shifted while the car is stopped, but I leave it in second gear all of the time.

Second gear provides a very enjoyable driving experience from zero to 55 miles per hour (probably more, but I haven't tried it).

The inverter input current is limited to 190 amps to protect the batteries (this is programmable). I've never timed it, but the acceleration from 0 to 50 is completely satisfactory (it is much more enjoyable than what the Corolla's original 1.8L engine provided).

Battery:

The traction battery pack consists of 26, Werker 44Ah lead-acid absorbed glass mat (AGM) batteries. I decided to go with the AGM batteries for two reasons. First, they are completely sealed so there is less worry about gas build-up (provided they are charged properly). Since they are completely sealed they are maintenance free and there is no chance for corrosion around the connections. Second, and perhaps most important, the batteries are non-spillable so there is no chance for leakage if the battery is damaged in an accident.

Six batteries are housed under the hood, four are under the back seat (the seat is still fully functional) and 16 are in the trunk. Most of the batteries are connected through 6 AWG braid, the longer runs between the three battery sections are connected with 4/0 welding cable.

The battery pack is connected to the inverter via a high-voltage contactor controlled by the inverter. The inverter measures the battery pack voltage through a trickle current before commanding the contactor to close. If anomalies are detected then the contactor is not closed and an error is indicated on the dashboard. While driving, if the battery voltage becomes too high or too low, or the motor shaft speed becomes too high, the contactor is opened to protect the system. These high and low thresholds are programmable. The contactor is also disabled through an inertia switch. Should the vehicle be involved in an accident, the inertia switch will open, immediately disconnecting the battery.

Each battery is connected to a small circuit board containing a DS2436 battery monitor that measures voltage and temperature. Each circuit board is optically isolated and tied to a separate controller board that contains a Xilinx Spartan-II Field programmable Gate Array (FPGA). The controller board communicates to the outside world through an optically isolated RS232 serial port. A laptop can then access each battery's voltage and temperature.

In the morning, after a complete charge, the battery voltages measure 12.98 ± 40mV. After returning from my 16.2 mile round-trip commute and after sitting for one hour, the voltages measure 12.42 ± 40 mV. The longest I have driven the car is 26 miles, with the A/C operating (during the summer when the increased temperature improves battery capacity).

Battery Charger:

The battery charger is a Manzanita Micro PFC-20 (http://www.manzanitamicro.com). The charger is water cooled via a small circulating pump and radiator. There were air cooled models available, but I decided the Arizona summer deserved some respect. The charger is housed in the trunk and is connected to the outside world through a plug housed behind the car's fuel filler door. The charger operates over a wide range of input voltages and the charge current is adjustable up to 20 amps. The charger contains a built-in timer that automatically shuts down the charger after a programmable amount of time. The timer starts when the battery pack voltage reaches a programmed voltage. A ground-fault circuit-interrupter (GFCI) protects the user from any unlikely defect during the charge cycle.

Air Conditioning:

The A/C compressor was never discharged during the conversion process as it was located where it could be easily tied out of the way of harm. I fabricated a small platform to hold a 1.5 HP, three-phase motor. A Toyota pulley was installed onto the motor shaft and a standard Toyota belt is used to connect the motor to the compressor. The motor is controlled by a programmable three-phase motor controller, modified to accept the 312V DC pack voltage. A small circuit board was designed to provide the necessary interface between the motor controller and the in-car A/C controls. The controller was programmed to maintain a constant motor speed at an efficient level (avoiding any clutch cycling) that provides comfortable cooling to the interior of the car.

Brakes:

The vacuum assist provided by the engine was maintained via a vacuum pump. The pump monitors the amount of vacuum in the system and engages automatically as necessary to maintain ease of braking. In addition, the regenerative braking provided by the inverter assists braking while returning some energy back to the batteries. The amount of battery current allowed during braking is programmable.

Steering:

The power steering was disabled when the engine was removed. I removed the power steering pump and connected the input and output of the steering together. This allows the remaining fluid to move freely when the wheel is turned. The result is steering that is somewhat more difficult when the car is stopped or moving slowly. It is NOT the same feel as when the engine dies and the wheel is very difficult to turn. My wife is able to steer the car without any problems.