Solar vehicle uses CAN for internal communication

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Introduction
Eco Solar Breizh association has taken a step forward to develop a solar car. The solar car will either extract the energy from the sun or from the kinetic energy of the vehicle. CAN networking is used for car's internal communication reduces the wiring inside the vehicle.

Eco Solar Breizh association currently develops a car to participate in the World Solar Challenge, which consists of cruising in Australia from north to south with a vehicle driven by energy that must either come from the sun or must be recovered from the kinetic energy of the vehicle itself.

Difficulty for the association in this quest is to choose the appropriate semiconductor offer to manage energy in the racing car from solar panel energy and battery management to motor drive, calculations and communication. Renesas Electronics Europe is currently providing a wide range of solutions covering low-power and standby modes (e.g. the Snooze mode) on the low-end 16-bit RL78 micro-controller (MCU) up to the enhanced 32-bit RX device. The company offers a large number of application notes, software examples, documentation and the information exchange by Renesas developers' community. This should ease the implementation of the MCUs for the developers.

There are several technical constraints for the development team. For example, the carbon structure of the chassis does not allow wireless communication. This is why the choice has been made to allow multiple back-up solutions for each task or system. To cite an example, the man-to-machine interface for the driver is possible via a smartphone with Android operating system spreading multiple information such as speed, battery level, etc. and enabling lights control. In parallel, direct command of lights via buttons has been taken in consideration during the main electronic calculator development phase. In addition, the size and weights limits are important parameters to be taken under consideration. A heavier vehicle would have worse acceleration, braking, cornering and energy efficiency. The development was also focused on the limited available energy. For example, the onboard vehicle battery has a limited amount of energy, while the solar cells generate a limited amount of power. On top of that, the race environment is harsh. The vehicle has to withstand vibrations and high temperatures that limit the power, which can be used.

CAN networking

Today, the development team is mainly focused on the electronic architecture, especially the implementation of the CAN network, which will permit to transmit crucial information to the ▷

Figure 1: The solar vehicle

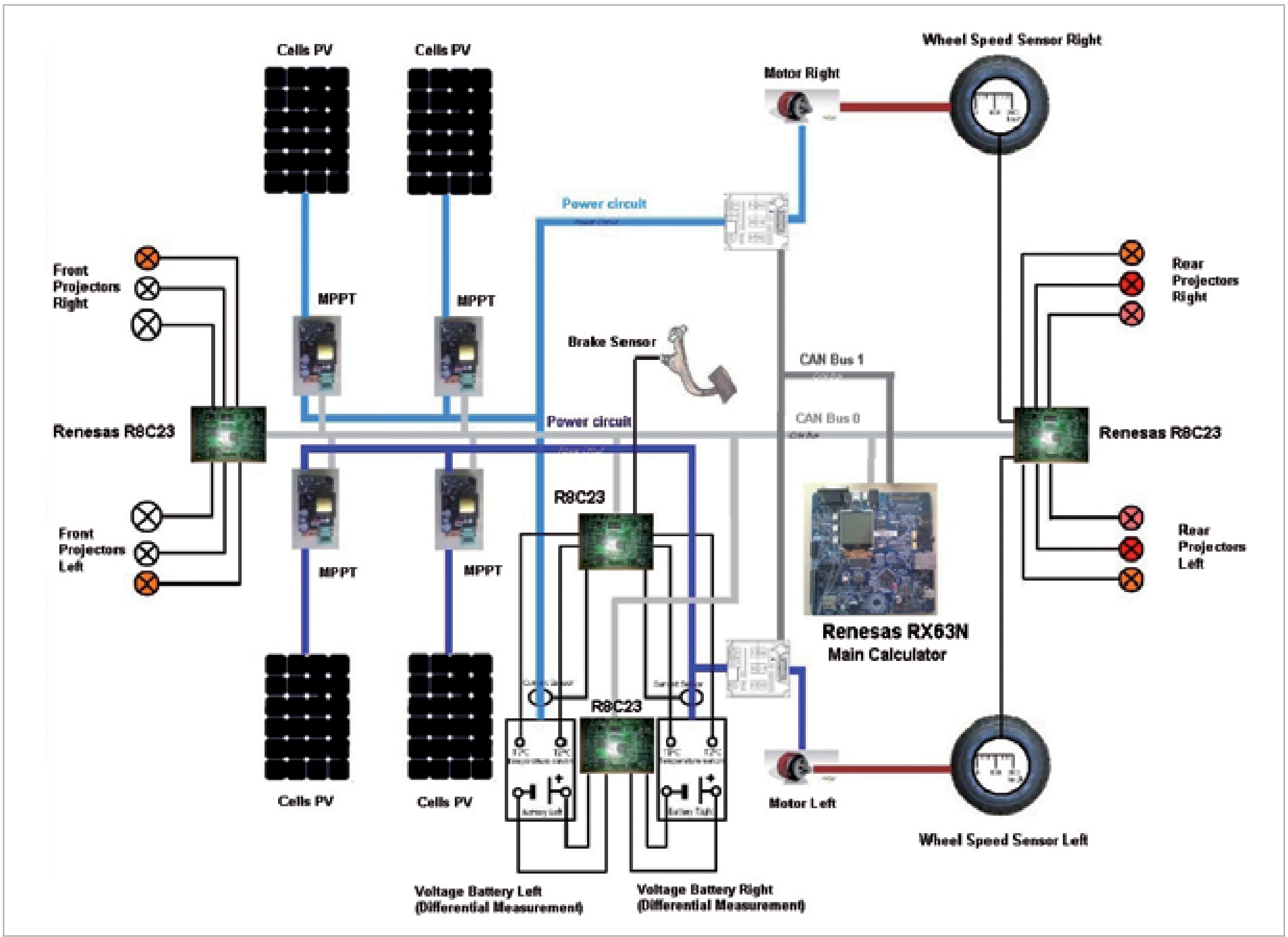

Figure 2: Solar vehicle block diagam

pilot. The use of CAN is explained by the fact of having a single communication network inside the vehicle. The advantages include a significant reduction of the wiring inside the vehicle, modularity and easy replacement of electronic boards. Usage of CAN also increases the security of the information that is exchanged using the voltage-difference-based transmission. CAN network structure allows having flexibility in the car development. Interest in terms of image is not negligible either, since CAN is broadly used in the automotive domain and illustrates the idea that the solar vehicle could be a ”real” car. Implementation of Renesas' devices into the vehicle was done jointly with the local application engineers from the company.

Data transmitted to the pilot

The main measurements transmitted on the CAN include e.g. currents and temperatures of the photovoltaic panels, vehicle speed, engine load (electrical BLDC motor), current through the battery, and current in each motor. A lot of the information is received by the driver via CAN and is displayed on a touch pad. The communication between the main computer (Renesas RX) and the Android tablet is today fulfilled via Bluetooth. The development team is also working on a back-up solution to implement USB connectivity, which allows charging of tablet batteries.

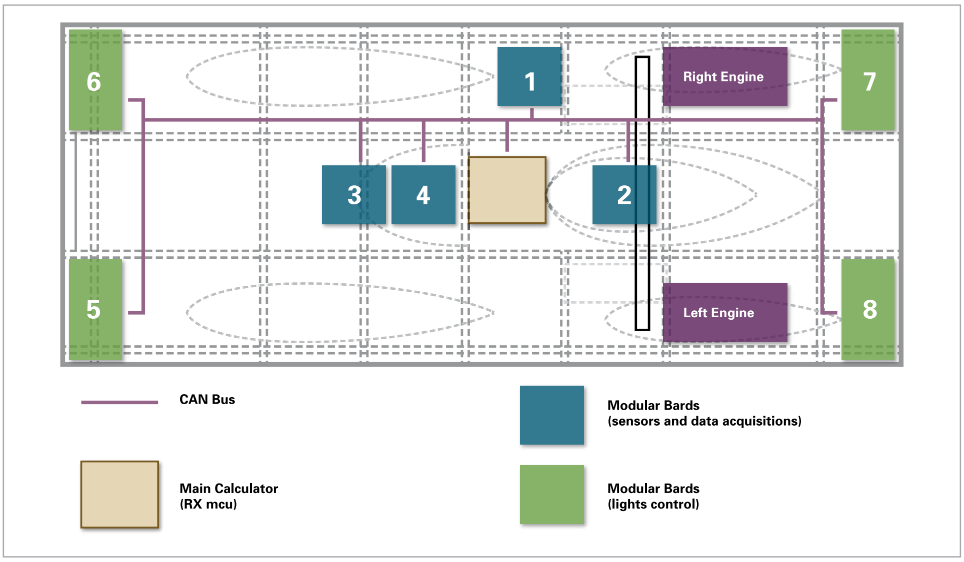

Figure 3: CAN network structure in the vehicle

Modular electronic board

The R8C 16-bit micro-controller offers the functionalities needed to develop a modular and adaptive electronic board able to manage different actions. For example, it can measure temperatures (batteries and photovoltaic boards), get simple signals, control the solar vehicle lights, and man- ▷

Developer
The aim of the Eco Solar Breizh association (France) is to compete in international solar-powered car races. The association is composed of private companies, academic institutions and volunteers. The first objective is to participate in the 2013 World Solar Challenge in Australia.

Development status
Today, the vehicle prototype is mechanically assembled in Brittany (France). The carbon structure is mainly finished. The solar panels are assembled and mounted. Specific batteries are currently under production. The motor control system is under benchmark testing, including mechanical aspects and electronic controller tuning. Innovation and research drive unified the development team. Since the beginning of the project in 2010, more than 75 students have participated in various developments, supervised by university graduates and industrial partners such as Renesas Electronics.

Related articles
B. Westhoff, CAN is easy to use!; in CAN Newsletter, September 2012

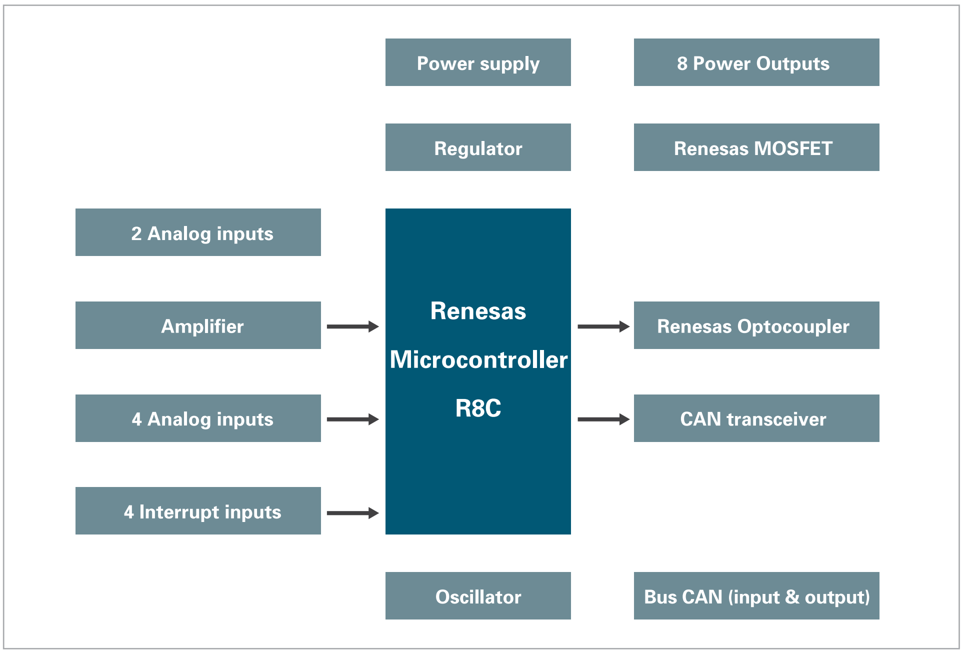

Figure 4: Modular electronic board architecture

age communication. These actions depend on where the team wants to setup this modular board into the solar vehicle. The device provides an on-board 10-bit A/D converter, data Flash, multiple timers and a CAN interface. The connected electronic boards are controlled by the main calculator (Renesas RX) via CAN. This functionality permits to reprogram the entire electronic system using the main calculator. To develop these electronic boards, Renesas also provided to the association such devices as micro-controllers, opto-couplers, and Mosfets.

Main calculator

As main calculator in the vehicle, the 32-bit RX micro-controller offers a good compromise between performance and current consumption. The architecture delivers 1,65 DMIPS/MHz with FPU (floating point unit) and DSP (digital signal processing) features, which allow performing up to 165 MIPS with a 50-mA current consumption at highest CPU clock frequency. The micro-controller is designed for power-efficient use allowing signals and data treatment or calculation. Main peripherals used in the developed system are CAN, UART, USB, timers and SD card interface. As described previously, the CAN is used for the communication between the main calculator and the different R8C modular boards, the DC/DC-Boost maximum ▷

Figure 5: Vehicle conception includes such developments as motor control

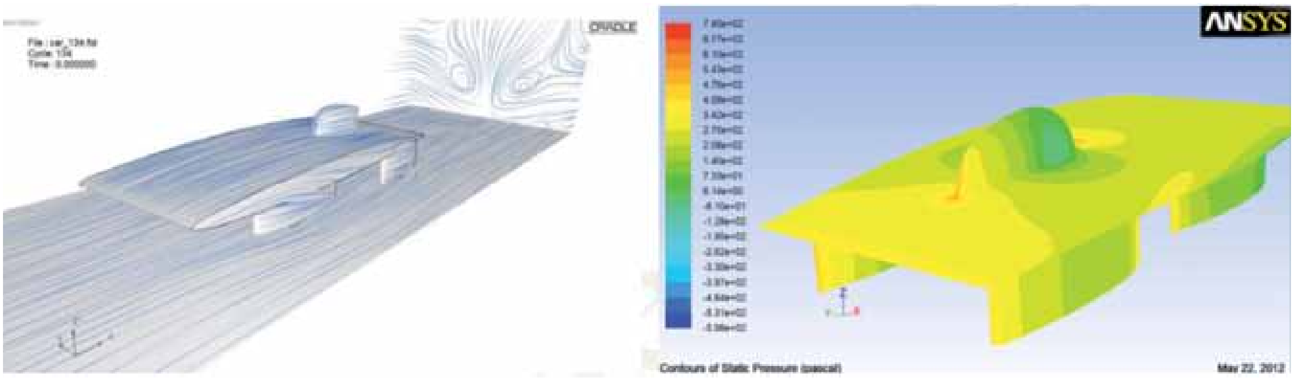

Figure 6: Vehicle modeling and simulation

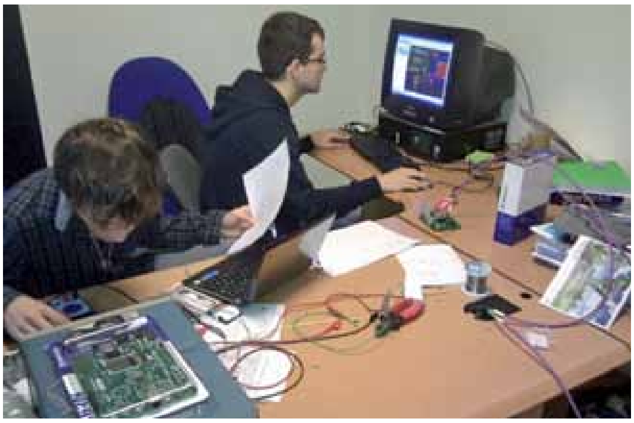

Figure 7: Several student groups are developing the project

power point tracker (MPPT) and the two electrical motor controllers. CAN messages received from each peripheral board can be displayed by the main controller on a terminal via the EIA-232 interface in case of vehicle debug tests. The timers are used to synchronize the sending of data to a smartphone via Bluetooth and also to trigger data recording into a data logger. The entire measurements are stored on an SD card, which allows analyzing recorded vehicle data after the tests and the race.

MCU for energy harvesting

Regarding specific sensors and information management, constraints in current consumption oblige the team to employ the low-power RL78 micro-controller to be capable to develop autonomous systems using energy harvesting in the vehicle. On this subject, development is confidential and ongoing, but only possible with the RL78 using the Snooze mode, introduced by the chipmaker. With this feature, the MCU can be set up to accept a periodic A/D conversion or a serial port reception, while keeping the CPU in stand-by mode. This lowers the overall battery current drain. In case of energy harvesting, this capability allows to analyze or store measurements using vehicle's kinetic energy. In the suspension conception, the RL78G13 has been implemented to measure the values of constraint sensors, which measure physical forces applied on the structure. In this system conception, there is no battery and the only source of energy is the mechanical vibration of the suspension. The MCU current consumption (combining snooze and active modes) is low enough to create such an autonomous system. The measurements of the constraint sensors (with 10-bit resolution after A/D conversion) are triggered every second by the RTC without the need to wake up the CPU. Then, it compares the digitized value with the upper and lower limit pre-established in two writable registers. In this vehicle example, the configuration is made to wake-up the CPU only if the ADC result is outside of these limits. As a result, it achieves 10 % of the power consumption compared with using of standard topology in the Run mode. For example, in the Snooze mode the device consumes 0,5 mA versus 5 mA in the Run mode (using ADC). The MCU is able to run at 1,6 V to 5,5 V and to fulfill A/D conversion at 1,6 V. This allows the RL78-based subsystems to run on very low harvested voltages. An internal analog reference voltage (1,4 V) allowing getting measures independent from the supply voltage, is available as well. RL78 also includes a temperature sensor used by the development team to record ambient temperature values. ◀