NXP GreenBox Vehicle Electrification Development Platform

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Introduction

As the demand for HEV/EV increases, so do regulations to lower emissions. Carmakers can require and make use of NXP's GreenBox development platform, a high-performance processing platform used to design and test control algorithms and energy management tasks. The GreenBox will help to develop the next generation of hybrid engines and electrification.

The development platform is composed of two microcontrollers, the S32S247TV and MPC5777C. As safety and performance are of great importance for hybrid and electric vehicles, the GreenBox platform satisfies these two requirements with the functionalities of the two MCUs. There are also highly optimized peripherals such as advanced timers, motor control, and analog sub-systems to interface with the hardware, shown in Figure 1.

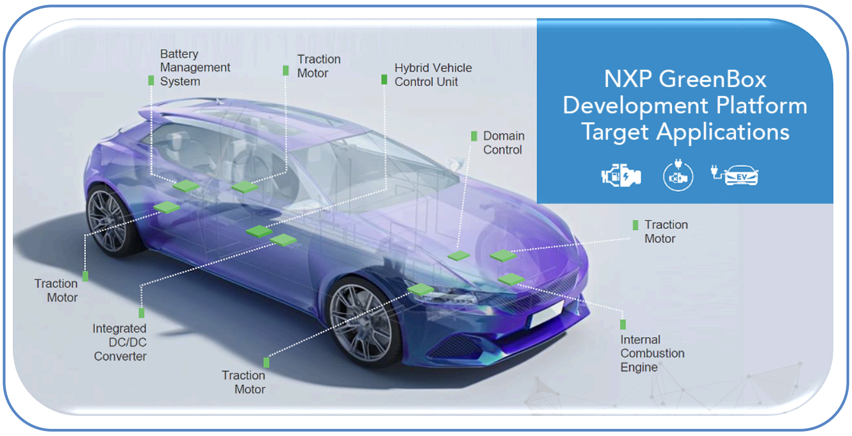

Figure 1: Systems that the GreenBox is capable of managing on an xEV

System Overview

The GreenBox is composed of two subsystems: a motherboard and daughter board. The S32S247TV is located on the motherboard and the MPC5777C is found on the daughter board. The two MCU's are communicating via Ethernet. Along with the two microcontrollers there are fail-safe SoCs and a MC33664 chip that are for safety and the battery management system (BMS).

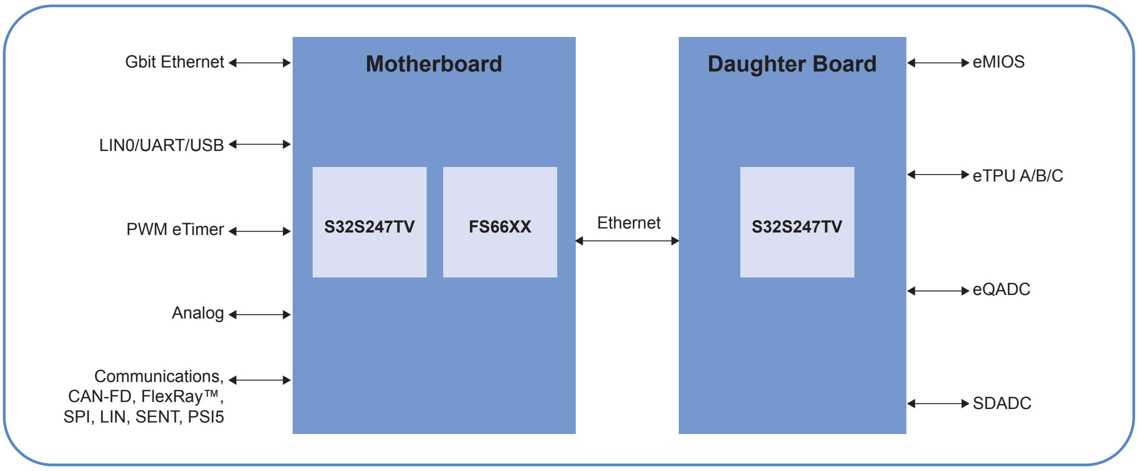

Figure 2: Block diagram of GreenBox.

S32S247TV Microcontroller

The S32S247TV microcontroller is an ASID D device with quad Arm® Cortex®-R52 processors in lock-step architecture, for a total of eight cores. The microcontroller is composed of three die, compute, application extension (AE), and flash memory. With such capabilities, the MCU supports virtualization and hypervisor. Installed application software controls the entire GreenBox II platform. By default, the S32S247TV microcontroller is configured to boot from the microSD card. The one interesting feature of the MCU is that it can manage two motors.

MPC5777C Microcontroller

The MPC5777C has two independent z7 cores, a single z7 core in lock-step in one of the main cores and is also an ASIL D device. The MCU is preprogrammed with firmware to do two functions: to respond to memory access requests from the S32S247TV microcontroller and forward interrupt requests to it. This MCU also provides access to advanced timers and ADC converters, such as enhanced timer processing units (eTPU), an enhanced queued analog-to-digital converter (eQADC), and a Sigma Delta analog-to-digital converter (SDADC). The ability of the MCU to interface with inverters, motors, engine control and the BMS adds to the key features of the GreenBox II platform.

Communication and Interfaces

Ethernet is the form of communication that is used between the motherboard and daughter board. These boards use Ethernet to communicate because it allows the S32S247TV to send "read and write" requests to the MPC5777C's memory and registers. There are two other serial communications used within the GreenBox device. The interrupt request (IRQ) and general-purpose input output (GPIO) allow for the flow of interrupts between the two MCUs. The IRQ will trigger the interrupt dispatcher on the S32S247TV and the interrupt code is then captured from the GPIO lines.

The following table (Figure 3) shows the additional forms of communication available and the number of ports. These serial communications are for external use.

Number of Ports	Interface	Number of Ports	Interface
1	Gbit	4	CAN FD
2	SPI	2	FlexRay
2	S.E.N.T.	1	PSI65
1	LIN	1	UART

Figure 3: The different serial communications and number of ports available

Use-Case: GreenBox Demonstration

NXP's has partnered with MathWorks® to create a processor-in-the-loop (PIL)/hardware-in-the-loop (HIL). The hardware used was NXP's S32S247TV MCU within the GreenBox platform and NXP's permanent magnet synchronous motor (PMSM) development kit. The software was MathWorks' Simulink® software and various toolboxes.

NOTE: The PMSM development kit is not part of the GreenBox platform, but a separate platform. The features of this use case were torque vectoring (TV), dual motor control, and an energy management strategy for HEV.

Torque vectoring is a method of control directed to each wheel to allow the torque applied to be of uneven distribution. This action occurs when a car is making a turn at a corner. The outside wheel will output more force than the inside wheel, since it runs for a longer distance. Variation of torque at each wheel is controlled by the stability control system (SCS). The SCS has a predefined understeering gradient, which when the vehicle surpasses it, the vehicle will be forced back to its stable state. The GreenBox platform has a feedback controller that provides improvement on various actions, such as increase in maximum lateral acceleration and higher yaw rate. With these enhancements, the vehicle's performance is increased in the areas of cornering capabilities, average lap time and less effort when performing maneuvers.

There are two hardware boards to assist with the motor control. The first one is the controller board, which is located inside the GreenBox II device. The controller board is able to manage two PMSM motors with ease. The motor control application is running on the S32S247TV in the motherboard via PCI Express®. Some of the features include vector control of the 3-phase PMSM with a resolver, cascade control structure with current and speed closed loop, and also 20 kHz switching frequency of PWM, among others. Another feature is the FreeMASTER project, which is used for real-time debugging and data visualization. It is also used for a graphical control page to control the motor and application faults monitoring and visualization. The second board is the 3-phase power stage board in the PMSM development kit. The 3-phase power stage board is capable of monitoring various types of motors such as PMSM, BLDC, or ACIM motors.

The GreenBox II platform has a dedicated SoC, the MC33664, for the BMS. The MC33664 SoC is a transceiver physical layer transformer driver. The slave sends the response message to the MC33664 SoC. The SoC then forwards the response message to the MCU. The slave sends pulse bit information to the MC33664, which the SoC will then convert to an SPI bit stream for the MCU to obtain.

Conclusion

The correlation to the issues between the high-demand of HEV/EV and the increase in emission regulation requires a solution. NXP's GreenBox development platform can address this issue with the appropriate microcontrollers, S32S247TV and MPC5777C. The two microcontrollers are within the GreenBox platform, , but are placed in two separate boards within the platform. The S32S247TV is more proactive than the MPC5777C MCU because the MPC5777C MCU comes preprogrammed with firmware. The two MCUs make the GreenBox platform capable of managing several peripherals, a BMS and many more HEV/EV applications.

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