# A High-Voltage Transceiver for Electrical Vehicle Battery Management Systems[1]

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***Abstract*** **–This work presents a high-voltage (HV) Transceiver used in Battery Interconnect Module (BIM) for electrical vehicle (EV) Battery Management System (BMS). To realize a HV (300 ~ 400 Volts) BMS for EVs, the HV Transceiver in the BMS shall be fabricated using an advanced HV semiconductor process to sustain high voltage drop of battery modules. Besides, the proposed HV Transceiver is better carried out without using any isolator. The proposed HV Transceiver is measured and proved to transmit and receive data with a -32 ~ +32V common mode voltage.**

**Key word: high voltage, battery management system, high voltage transceiver.**

## I. Introduction

For the sake of green power, the trend of vehicle development will be toward the battery-operated electrical vehicles (EV). Fig. 1 shows a conceptual power system of EVs. BMS is in charge of monitoring the battery status of Battery Modules, including voltage, current, and temperature. BMS also analyses the battery status to calculate the state-of-charge (SOC) and state-of-health (SOH). Finally, the battery status will be transmitted to the driver through Automobile Networking Systems, e.g., FlexRay protocol [1], which is meant to control and communicate with all ECU nodes.

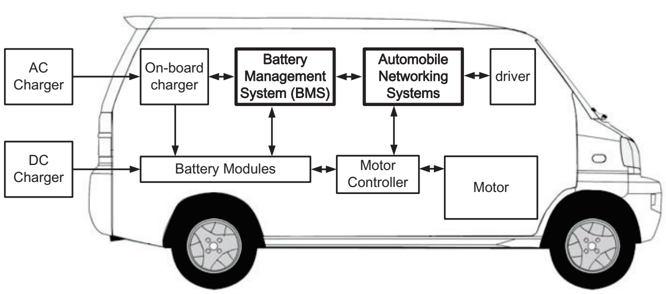


Fig. 1. A conceptual power system of EV.

One of the most popular BMS architectures is the modular formation, e.g., O2Micro OZ890 [2]. A typical custom BMS is shown in Fig. 2, where each BIM module monitors several batteries with a daisy-chain interface. Meanwhile, the battery status can be transmitted and received between adjacent BIMs by HV Transceiver (with Upper BIM Link and Lower BIM Link). However, the communication methods between adjacent BIM chips were usually realized with discrete components, e.g., opto-coupler and magnetic coupling [3]. Therefore, these extra discrete components will generate complexity, heat, and cost problems in a large-scale BMS system.

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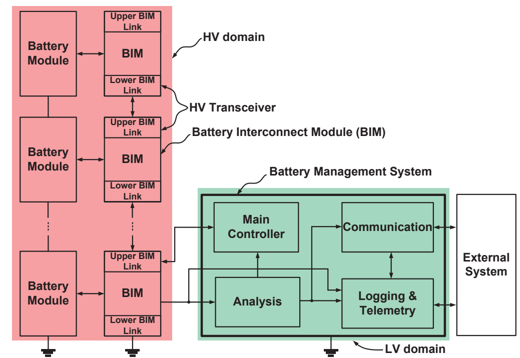


Fig. 2. Explosive view of a typical distributed BMS.

## II. A High Voltage Transceiver for EV BMSs

The proposed HV Transceiver is composed of Upper BIM Link and Lower BIM Link, as shown in Fig. 3. Upper BIM Link is used to communicate with the upper adjacent BIM by TX_H and RX_H. By contrast, Lower BIM Link is in charge of communicating with the lower adjacent BIM by TX_L and RX_L. Notably, RX_H must be sustainable to receive positive HV signals, e.g., the common mode voltage is 16 ~ 32 V in a series of 8 batteries from the upper adjacent BIM, and RX_L is expected to receive negative HV signals (common mode voltage: -16 ~ -32 V) from the lower adjacent BIM.

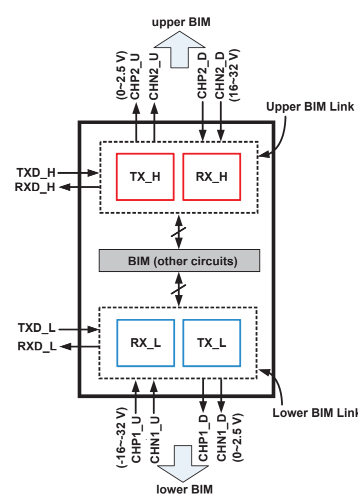


Fig. 3. Floorplan of HV Transceiver in a BIM.

### A. TX_H and TX_L

The two transmitters, TX_H and TX_L, are used to transfer data to upper and lower adjacent BIMs at the same time, respectively. Therefore, they are realized using same circuits to convert TXD_H (or TXD_L) to CHN1_D and CHP1_D (or CHN2_U and CHP2_U). Most important of all, the voltage swing of all outputs is from VDD25 (2.5 V) to GND (0 V).

 

### B. RX_H and RX_L

To receive data from upper and lower adjacent BIMs, the two receivers, RX_H and RX_L, must convert the positive and negative HV signals (16 ~ 32 V and -16 ~ -32 V) into 0 ~ 2.5 V. Notably, they are equipped with HV tolerance. Fig. 4 shows the schematics of RX_H and RX_L, including two converting circuits and a comparator with hysteresis. The converting circuit has to convert the CHP2_D and CHN2_D into the input range of the following comparator. Each converting circuit consists of OTA, R121 ~ R124, generating CCP and CCN voltage references. Finally, the comparator can compare CCP with CCN to generate RXD_H.

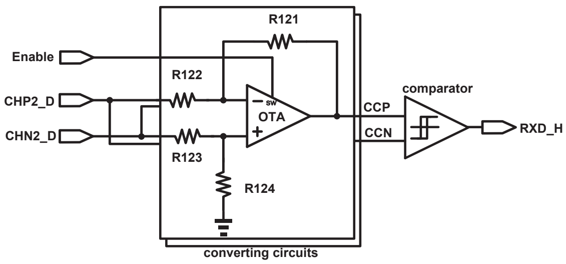


Fig. 4. Schematics of RX_H and RX_L.

## III. Implementation and Measurement Results

The proposed design is implemented using 0.25 μm 60V BCD process, as shown in Fig. 5. A photo of the measurement prototype with the proposed HV Transceiver used in the BIM is shown in Fig. 6. Besides, the measurement setting of the proposed HV Transceiver is connecting two BIMs, where TXD1 is the input data. The lower BIM transmits data to the upper BIM by CHP_U and CHN_U. The upper BIM receives the data to generate RXD2, and then it transmits the data to the lower BIM. Finally, the lower BIM receives the data to generate RXD1. All of the measurement results are shown in Fig. 7. All of these signals, TXD1, RXD2, RXD1, should demonstrate the same logic values, except the delays therebetween. The propagation delays are 36.45 ns and 26.83 ns, respectively. Besides, the maximum date rate from TX_H to RX_L and from TX_L to RX_H are 70 Mbps and 36 Mbps, respectively. The performance of the proposed HV Transceiver is summarized and compared with prior work in the Table I. Most important of all, no isolator or any discrete component is needed in our proposed HV Transceiver.

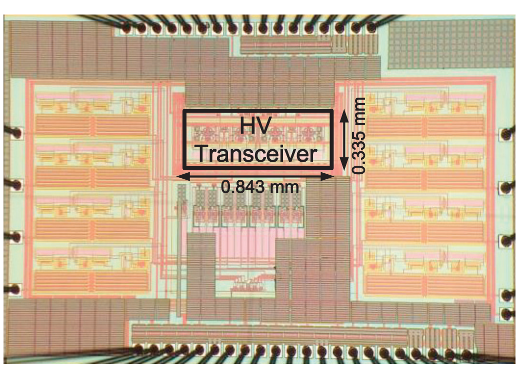


Fig. 5. Die photo of the proposed design.

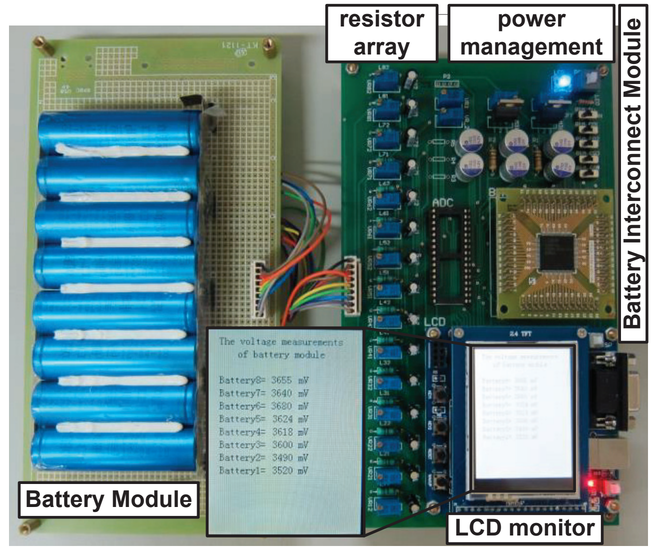


Fig. 6. Photo of the measurement prototype with the proposed HV Transceiver used in the BIM.

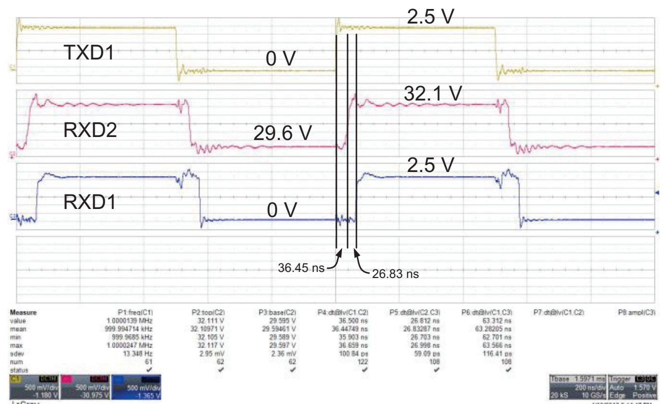


Fig. 7. Measurement results of HV Transceiver.

TABLE I
COMPARISON TABLE OF THE PROPOSED DESIGN AND PRIOR WORK

| | This work | [3] |
|---|---|---|
| Year | 2014 | 2012 |
| Process (μm) | 0.25 μm 60 V BCD (Only using the 2.5V MOSs) | 5V CMOS |
| Maximum data rate | 70 Mbps | 250 Mbps |
| Number of isolator | 0 | 2 transformers |
| Propagation delay | 26.83 ~ 36.45 ns | 5.5 ns |
| Power dissipation | 10.1 mW | 8 mW |
| Area | 0.282 mm$^2$ | 0.12 mm$^{2\dagger}$ |
| | 2×(Tx & Rx) | 1×(Tx & Rx) |

(†) Not include the area between Tx and transformer

## References

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