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New Developments in CompoNet Implementation

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Technical Track

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Currently Available CompoNet Chip Set

Physical layer components

- ▶ RS485 transceivers
 - Only 5-V power supply voltage
 - some vendors may prefer 3.3V power supply in their products.
 - ▶ transformers
 - Currently available transformers are not small enough to satisfy all applications.
- >An examination was made on how to use a much smaller pulse transformer and a 3.3V RS485 transceiver.

ASIC and CPU

- CompoNet needs two chips.
- >An examination was made on how to integrate those two, ASIC and CPU, into a single chip and what should be considered.

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Criteria for physical layer components

Transmission Amplitude

- ▶ 1.57 – 2.12 V

Receiver sensitivity

- ▶ ± 50 mV

Transmission impedance

- ▶ 750 kHz : 137 - 160 Ohms
- ▶ 1 MHz : 143 - 166 Ohms
- ▶ 1.5 MHz : 154 - 180 Ohms
- ▶ 3 MHz : 181 - 210 Ohms
- ▶ 4 MHz : 194 - 225 Ohms

Receive impedance

- ▶ 750 kHz : 847 - 985 Ohms
- ▶ 1 MHz : 821 - 955 Ohms
- ▶ 1.5 MHz : 754 - 877 Ohms
- ▶ 3 MHz : 558 - 649 Ohms
- ▶ 4 MHz : 477 - 554 Ohms

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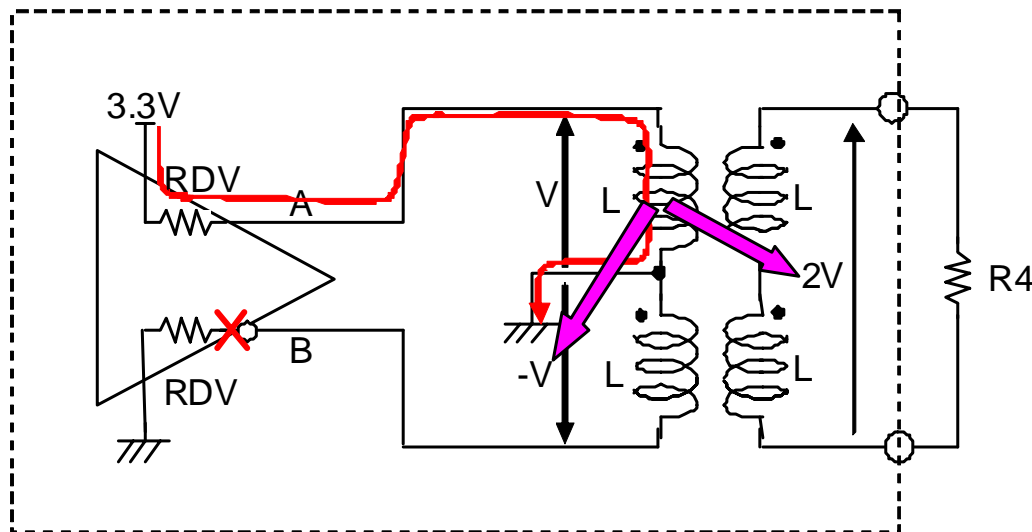
Issues concerning 3.3V transceivers

Receiver

- ▶ Receiver sensitivity ± 50 mV
 - Normally, a RS485 transceiver has receiver sensitivity in ± 200 mV.

Driver

- ▶ Amplitude and transmission impedance
 - Bigger impedance reduces amplitude. Examinations must be made to explore the possibility of balancing the two with 3.3-V power supply.
- ▶ In order to satisfy the criterion of transmission impedance, the transceiver must not generate current when the output is low.

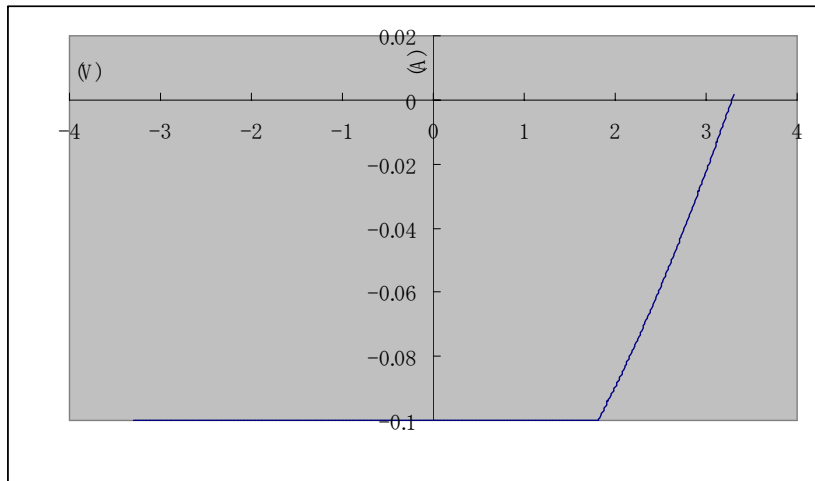


Impedance lessens if terminal B has current flow while a voltage V is applied.

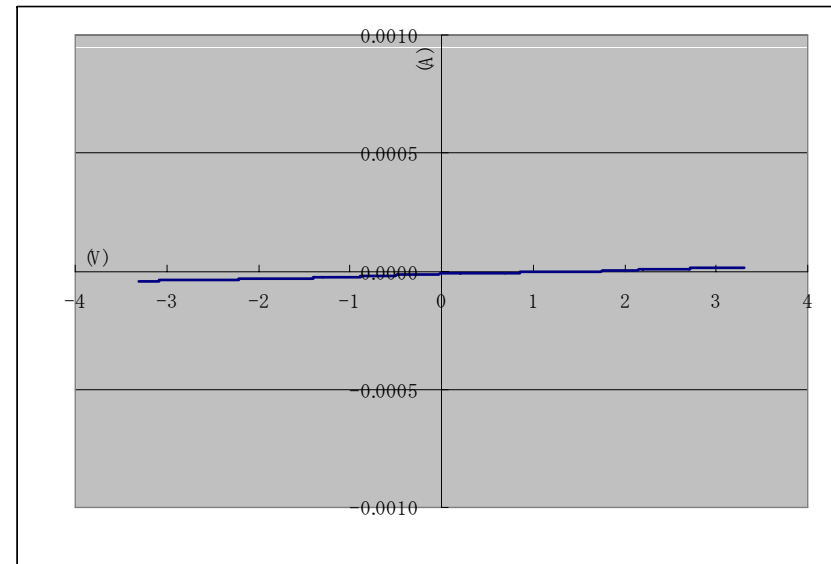
Selecting RS485 transceivers of 3.3V

An IC may need to be modified by the manufacturer to have high impedance and not generate current when the transceiver output is low.

VI curves of 3.3-V transceivers for the IC are shown in below.
From VI curves , $R_{DV} = 14 \Omega$



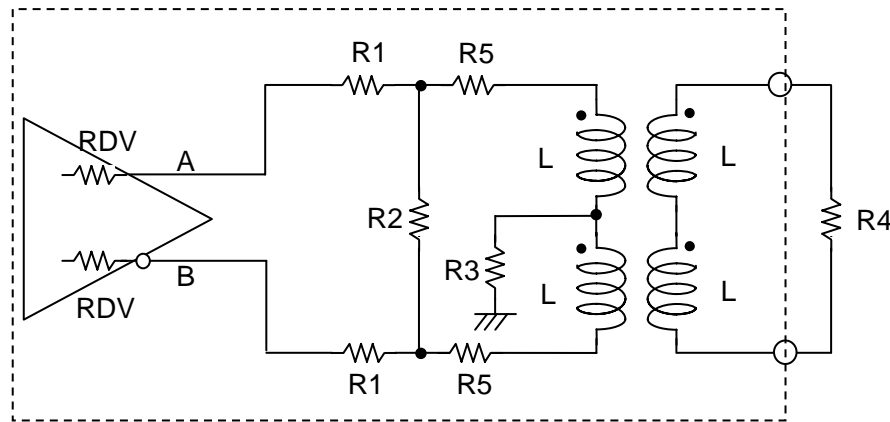
Output Current vs. Differential Driver Output **High** Voltage



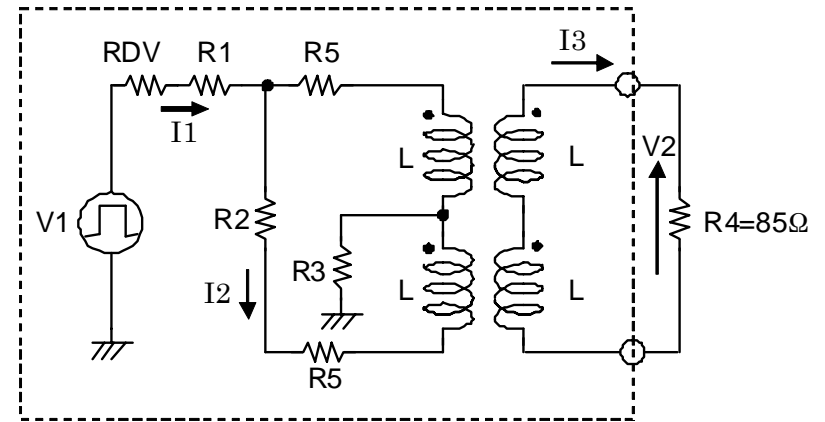
Output Current vs. Differential Driver Output **Low** Voltage

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Circuit at transmission



Basic circuit of CompoNet



Circuit at transmission

The calculation formula using Laplace Transforms is as follows

$$\begin{pmatrix} sL + RDV + R1 + R3 + R5 & -s(1+k)L - R5 & -2skL \\ -s(1+k)L - R5 & 2s(1+k)L + R2 + 2R5 & 4skL \\ -2skL & 4skL & 2s(1+k)L + R4 \end{pmatrix} \times \begin{pmatrix} I1 \\ I2 \\ I3 \end{pmatrix} = \begin{pmatrix} V1 \\ 0 \\ 0 \end{pmatrix}$$

Where k is the combination coefficient.

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Examination by theoretical formula

The following formulas can be derived from the previous ones.

$$\text{Transmission impedance} = \frac{4 \cdot (RDV + R1 + R3) \cdot (R2 + 2 \cdot R5) + 4 \cdot (R2 + R5) \cdot R5}{(R2 + 2 \cdot R5) + 4 \cdot (RDV + R1 + R3)}$$

$$\text{Receive impedance} = \frac{2 \cdot R2}{(R2 + 2 \cdot R5) + 4 \cdot (RDV + R1 + R3)}$$

When the transmission rate is assumed to be 1.5 MHz, the impedances are:

RDV=14 Ω, R4=85 Ω, V1=3.3 V, V2=1.845 V, Rin=815.5 Ω, Rout=167 Ω.

Using the above formula, the resistance constants in the slave units, (R1+R3), R2 and R5 are calculated:

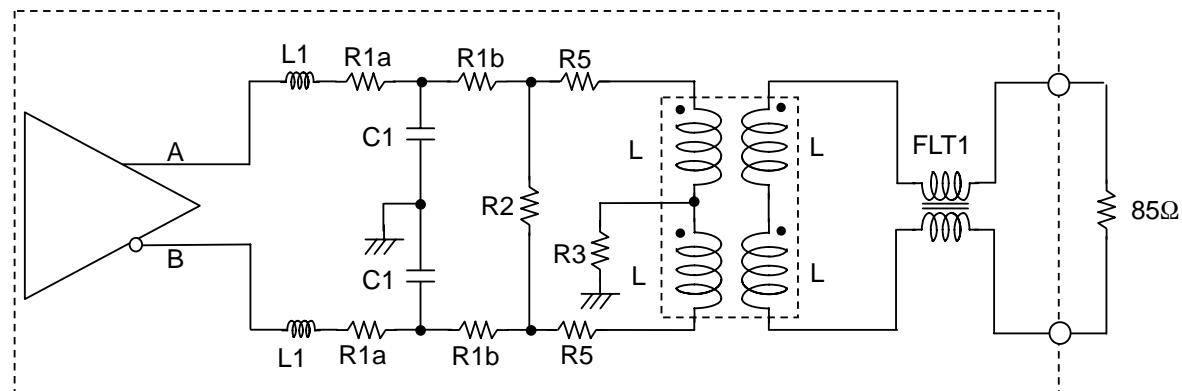
$$R2 = \frac{2 \cdot R4 \cdot V1 \cdot (Rin - Rout)}{V2 \cdot (R4 + Rout)} = 782 \qquad R5 = \frac{Rin - R2}{2} = 16.75$$

$$R1 + R3 = \frac{R2 \cdot R4 \cdot V1}{2 \cdot (R4 + Rout) \cdot V2} - \frac{Rin}{4} - RDV = 18$$

Confirmation by simulation

The Receive impedance is influenced by C1 but not by L1. The transmission impedance is influenced both by C1 and L1. Therefore after C1 is determined by the Receive impedance, the frequency influence on the transmission impedance is adjusted by L1. The resistance R1 and R2 must also be modified.

$R1a = R1b = 5.1\Omega$, $R2 = 910\Omega$, $R3 = 0\Omega$, $R5 = 16\Omega$, $C1 = 130\text{ pF}$, and $L1 = 1\text{ }\mu\text{H}$.



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Simulation result

The results of amplitude, Receive impedance, and transmission impedance are acceptable in all frequencies.

	CompoNet specification			Simulation result		
Frequency (Hz)	Amplitude	Transmission impedance	Receive impedance	Amplitude	Transmission impedance	Receive impedance
750K	1.57-2.12	847-985	137-160	2.059	920.69	155.7
1M		821-955	143-166		890.97	157.2
1.5M		754-877	154-180		818.32	161.5
3M		558-649	181-210		599.53	184.5
4M		477-554	194-225		490.47	208.7

Simulator: Microwave Office (AWR)

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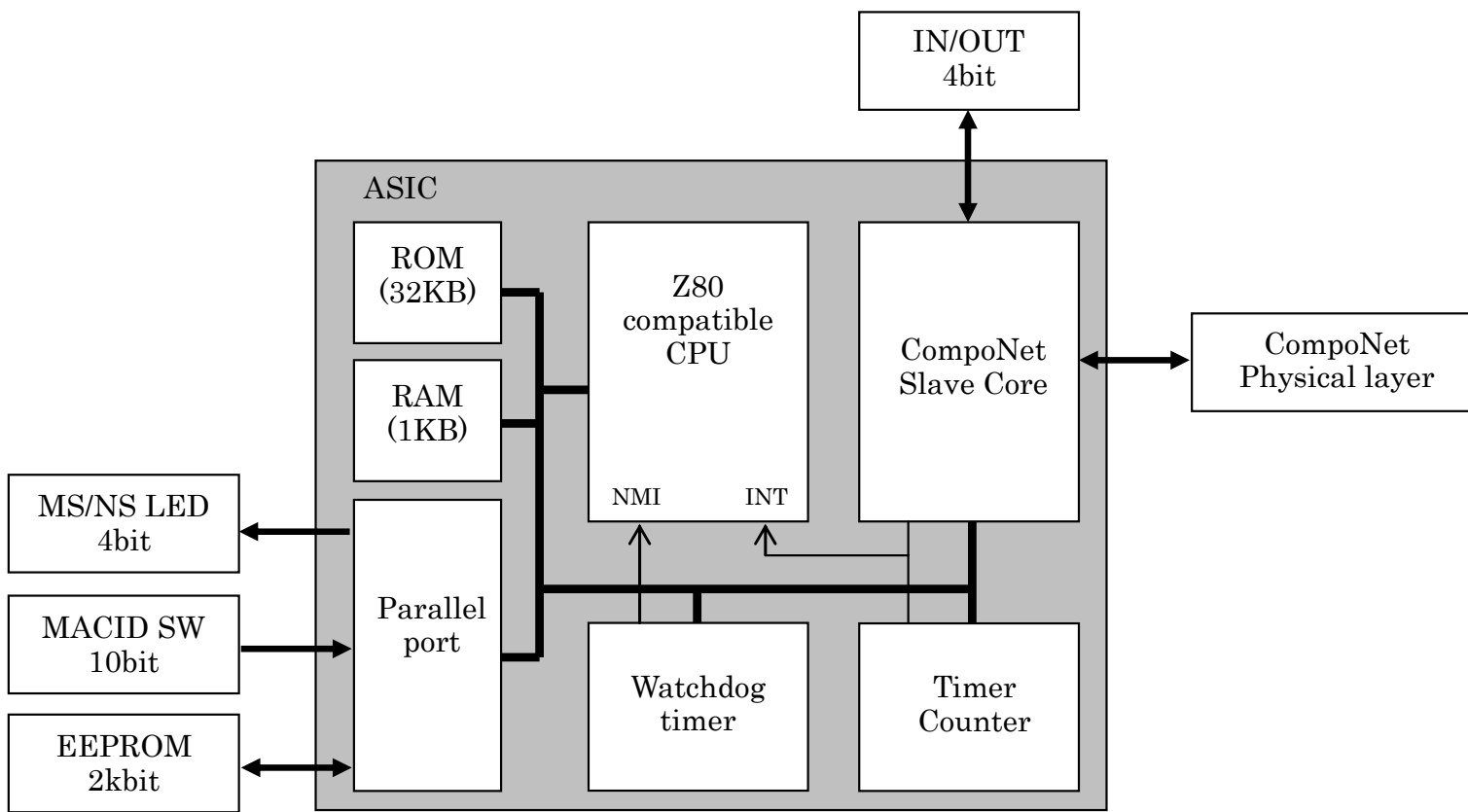
Requisite functions for a bit-slave ASIC incorporating CPU functions

The functions required for a bit-slave ASIC incorporating CPU functions include:

- ▶ Data processing of 4-point IN/OUT
- ▶ Object implementation requirements for CompoNet discrete I/O
- ▶ MS/NS indicators, and switch setting of MAC IDs
- ▶ EEPROM access
- ▶ Watchdog timer to detect CPU overrun

Example of an ASIC incorporating CPU functions

In this way software runs on a Z80 compatible CPU at 16 MHz, with 32-KB ROM, and 1-KB RAM. This proves that an extremely small ASIC can incorporate CPU functions, and that further device cost reduction and downsizing is achievable.



Conclusion

The examinations described in this paper presented the way for designing your own components in CompoNet physical layer, ASIC and CPU and for improving the chip sets.

As for the issues concerning the physical layer, only simulation has so far been accomplished. Verification shall be made with actual components and by connecting in a system.