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Application Note

SimpliPHY Transformerless Ethernet Designs

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Microsemi

a Microchip company

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1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 2.0

Revision 2.0 was published in June 2018. There were no changes to technical content in this revision.

1.2 Revision 1.2

Revision 1.2 was published in May 2016. In revision 1.2 the following changes were made:

- Diagrams of third-party PHY termination were corrected.
- Details about backplane applications were updated in the Transformerless Applications section.

1.3 Revision 1.1

Revision 1.1 was published in November 2007. In revision 1.1 of this document, the Connecting a SimpliPHY to an Externally Biased Line Driver (Preferred Method) diagram was updated.

1.4 Revision 1.0

Revision 1.0 was published in July 2006. It is the first publication of this document.

2 Overview

This application note describes a specific application called Transformerless Ethernet. Transformerless Ethernet is used, primarily, for two purposes:

- To support backplane applications (such as PICMG)
- To support point-to-point on-board copper media Ethernet connections

Microsemi's copper PHY line driver technology is a key feature in the SimpliPHY™ product portfolio, making these devices ideal for use in transformerless applications.

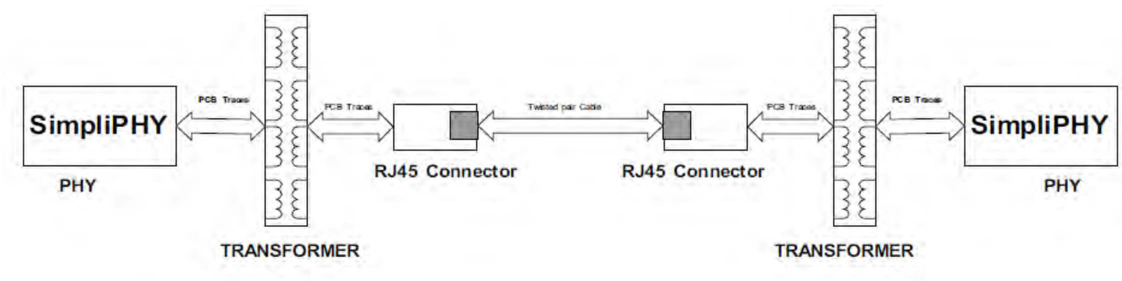
2.1 Typical Ethernet Application using Transformers

In a typical Ethernet application, connections between PHYs are made over unshielded twisted pair (UTP), 100 Ω, category 5E cable. The front-end interface components consist of a transformer, an RJ-45 connector, as well as several termination resistors and bypass capacitors.

One purpose of the transformer is to eliminate the incoming DC signal component introduced in the transmitted signals as a result of different ground references between the two communicating entities. The transformer is not required if the communicating devices share a common ground and/or the transceivers do not use the magnetics for any other purpose (such as sourcing current or providing a common-mode voltage into the transceiver), which is typical of current-mode line driver PHYs.

The following figure shows the typical Ethernet application using a transformer.

Figure 1 • Typical Ethernet Application Using a Transformer

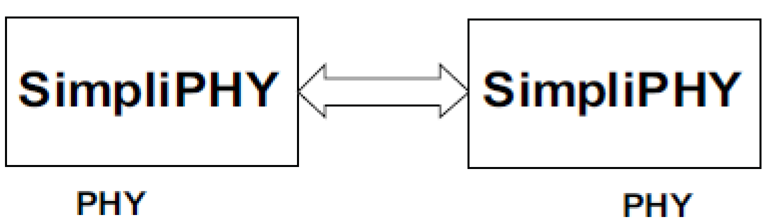


2.2 Transformerless Applications

When two copper PHYs are interconnected through printed circuit board traces (as opposed to a UTP cable), there is no longer any need for a transformer. This interconnection can be either two PHYs on the same board (permanently linked together through signal traces), or it can be PHYs on blade cards connected together via backplane bus within a single chassis system. The removal of the transformer and the RJ45 connector allows for Bill of Material (BOM) cost savings and can simplify the PCB layout.

The following image shows the trasformerless Ethernet application.

Figure 2 • Transformerless Ethernet Application



It is important to note that specifications developed by the PCI Industrial Computers Manufacturers Group (PICMG group) use Gigabit Ethernet transceivers over backplanes. As an example application, the AdvancedTCA® Base Interface specified in PICMG 3.0 could use a transformerless interface to implement board-to-board 10/100/1000 Mbps connectivity. For more information about the PICMG specification, see http://www.picmg.org.

3 Transformerless Design

Output line drivers of transceivers can be classified as current-mode or voltage-mode-based. Typical current-mode PHYs generate their output waveforms by sinking a current through the center tap of the primary winding of the transformer. The transformer is also used to provide the necessary common mode voltage for the PHY.

On the other hand, SimpliPHY transceivers use voltage-mode drivers where the center taps of the transformer are not used to generate the common-mode volatage and the sink current. Therefore, SimpliPHY transceivers support transformerless 10/100/1000BASE-T operation without any additional circuitry.

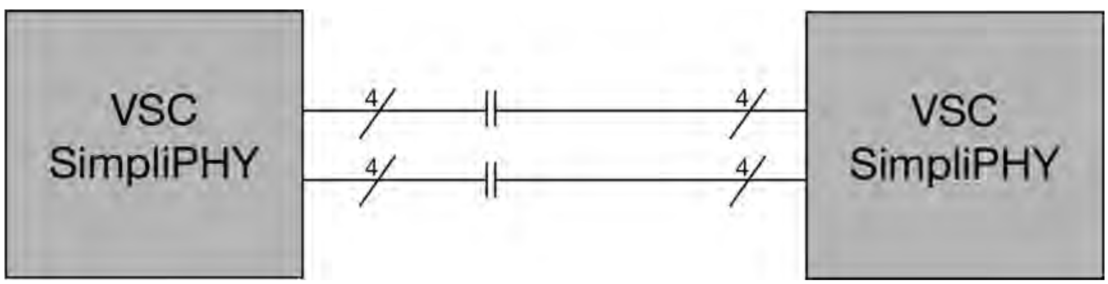
For more information about the differences between voltage-mode and current-mode-based PHYs, please refer to the SimpliPHY Architecture Advantages white paper.

It is important to differentiate the two line driver architectures used by PHYs because the methods of connecting them together require slightly different design techniques, as described in the following sections.

3.1 Connecting Two SimpliPHYs Together

If two Microsemi SimpliPHY devices are on the same design, then the copper interfaces of the two PHYs can be directly connected with 100 Ω differential signal traces through DC blocking capacitors to prevent common-mode voltage mismatches.

Figure 3 • Connecting Two SimpliPHYs Together



3.2 Connecting a SimpliPHY to an External Common-Mode PHY

Unlike a SimpliPHY device, a current-mode PHY is an example of a PHY requiring an externally generated common-mode voltage. These PHYs have a distinct disadvantage with transformerless applications because of this legacy architecture. The following illustrations show two acceptable methods, the latter being the preferred method, employed to address this issue.

Warning: A suitable common-mode termination strategy (as reflected in the figure below) must be verified by the non-Microsemi PHY vendor.

Figure 4 • Connecting a SimpliPHY to an Externally Biased Line Driver (Acceptable Method)

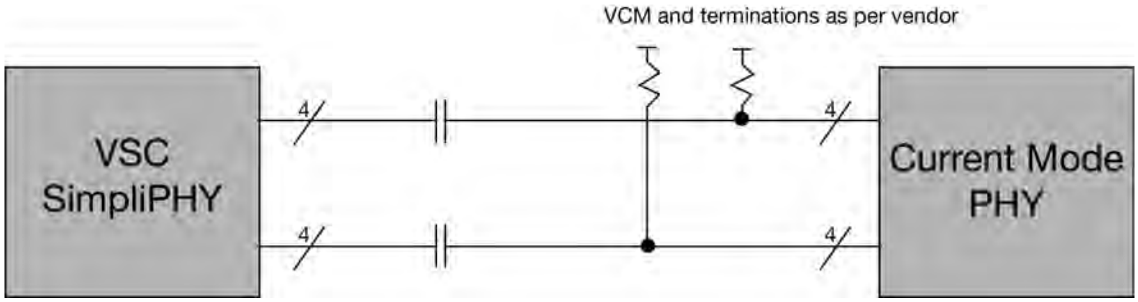
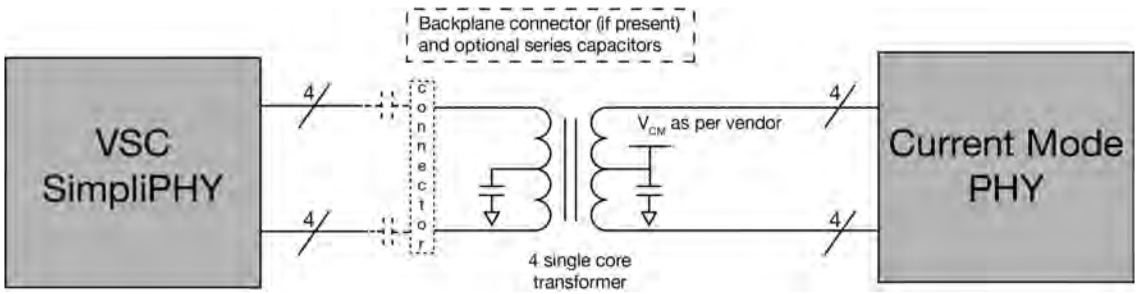


Figure 5 • Connecting a SimpliPHY to an Externally Biased Line Driver (Preferred Method)



Both solutions address the need of the current-mode PHY requiring a common-mode voltage on its differential interface. The acceptable method may use pull-up resistors to emulate the use of the center tap of the transformer. Depending on the circuit topology inside the non-Microesmi PHY's line driver, additional circuit connections may be required.

In order to better balance the connection, thus mitigating a differential-mode noise source and increasing link robustness, the preferred method still employs a transformer. Because EMI and other issues usually corrected by a magnetic when used with a twisted pair cable are not present, a very simple 4-core (single core on 4-pairs) transformer can be used (as opposed to a standard 8- or 12-core magnetic).

If the two PHYs are on different boards (for instance, in a backplane application), then DC-blocking series capacitors are needed between the SimpliPHY device and the backplane connector. The 4-core transformer should be located on the card with the current-mode PHY.

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