AN2190

Transformerless Applications of Microchip's Ethernet Devices

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INTRODUCTION

Applications which are sensitive to cost, utilize short distance PCB connections, or even extreme environmental conditions like temperature may benefit from operation without the use of a transformer. A magnetic-less design could be applied anywhere when two known fixed Ethernet devices need to communicate over a known distance.

This application note provides guidelines for connecting two Microchip Ethernet devices together without a transformer.

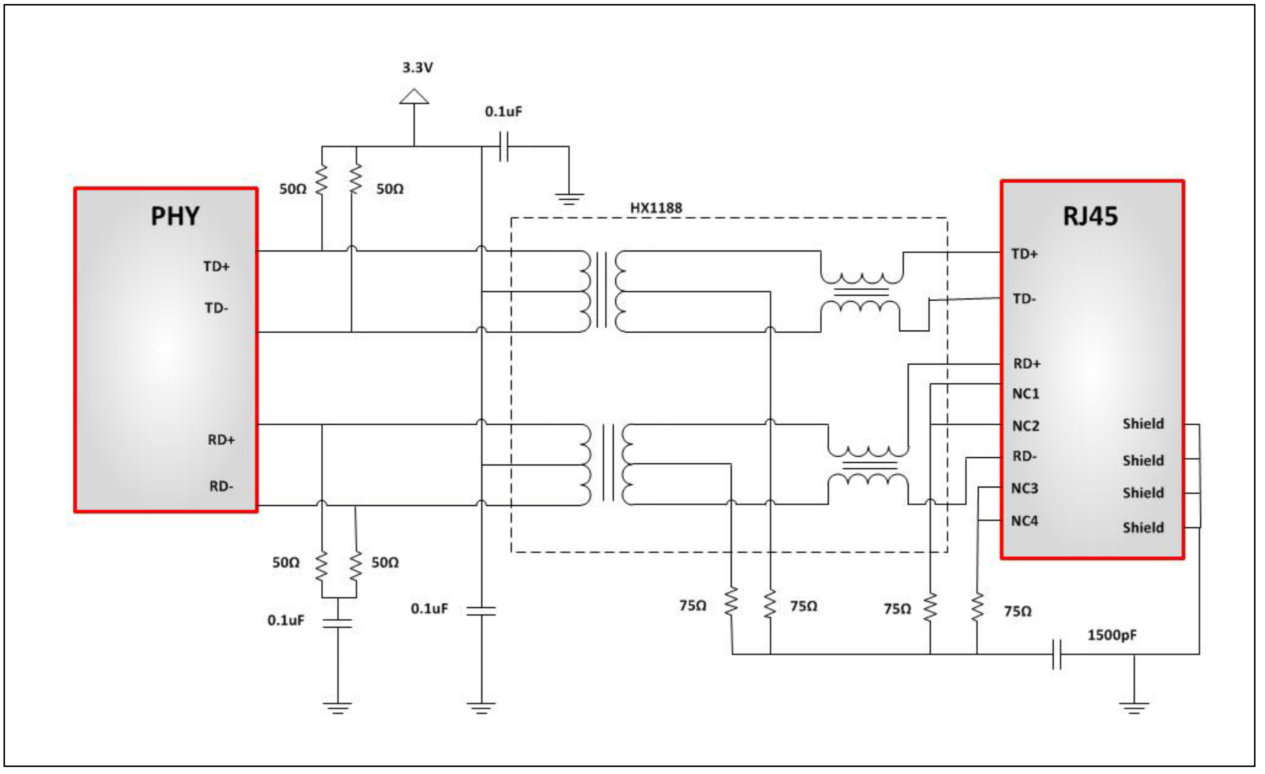
Note:	For information on transformerless operation of the LAN9252, refer to the Transformerless Applications of Microchip's LAN9252 EtherCAT® Controller application note. For information on transformerless operation of the LAN9250/LAN935x, refer to the Transformerless Applications of Microchip's LAN9250/LAN935x Ethernet Controller and Switches application note.

TYPICAL TRANSFORMER ISOLATION

To appreciate non-typical transformerless application development constraints, it is first necessary to understand physical network services and signaling, and the functions that transformers provide in typical applications.

A typical network configuration consists of a point to point connection, through a cable, between two physical layer devices. Figure 1 shows a schematic for a typical transformer interface. The transmitter and the receiver of each node are DC isolated from the network cable by 1:1 transformers.

FIGURE 1: TYPICAL TRANSFORMER ISOLATION



TRANSFORMERLESS CONFIGURATION

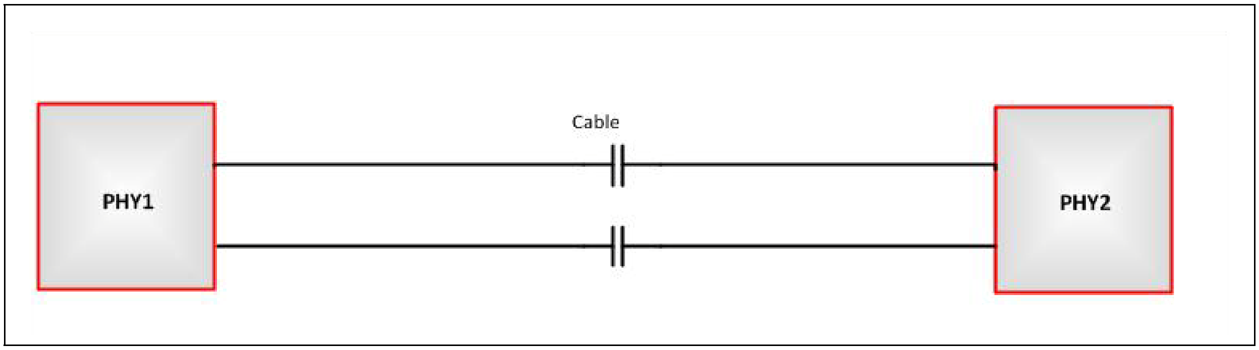
To meet the operational requirements of non-typical transformerless network applications, physical layer component transmit and receive separation and biasing as well as high voltage DC isolation to meet the specific safety requirements of the application must be implemented.

For non-typical applications, the isolation that the transformer provides in typical configurations can be realized using non-polarized capacitors.

A typical network configuration provides the services of Auto-Negotiation, Auto-MDIX, 10 Mb/s operations and 100 Mb/s operations. Auto-Negotiation and Auto-MDIX must be disabled in a transformerless application because both ends of the link are under local control. The system designer can configure a specific speed and duplex on both devices to ensure proper communication.

The IEEE 802.3–2008 specification requires the TX and RX lines to run in differential mode.The TXP and TXN lines form a differential pair and need to be designed to 100Ω differential impedance for long distances and 50Ω differential impedance for short distances. The RXP and RXN lines also form a differential pair and need to be designed to appropriate differential impedance targets.

FIGURE 2: TYPICAL TRANSFORMERLESS ISOLATION - CONNECTING TWO PHYS TOGETHER



AUTO-NEGOTIATION

The purpose of the Auto-Negotiation function is to automatically configure the transceiver to the optimum link parameters based on the capabilities of its link partner. Auto-Negotiation is a mechanism for exchanging configuration information between two link-partners and automatically selecting the highest performance mode of operation supported by both sides. In transformerless applications, Auto-Negotiation must be disabled in the Microchip device.

Disabling Auto-Negotiation via Registers

Auto-Negotiation can be disabled by clearing the Auto-Negotiation Enable (PHY_AN) bit of the PHY Basic Control Register (PHY_BASIC_CONTROL). The transceiver will then force its speed of operation to reflect the information in the PHY Basic Control Register (PHY_BASIC_CONTROL) Speed Select LSB (PHY_SPEED_SEL_LSB) and Duplex Mode (PHY_DUPLEX) bits. These bits are ignored when Auto-Negotiation is enabled. Refer to the specific Microchip device datasheet for additional information.

PHY Basic Control Register (PHY_BASIC_CONTROL)		
Bits	**Description**	**Type**
13	**Speed Select LSB (PHY_SPEED_SEL_LSB)** This bit is used to set the speed of the PHY when the Auto-Negotiation Enable (PHY_AN) bit is disabled. 0: 10 Mbps 1: 100 Mbps	R/W
12	**Auto-Negotiation Enable (PHY_AN)** This bit enables/disables Auto-Negotiation. When enabled, the Speed LSB (PHY_SPEED_SEL_LSB) and Duplex Mode (PHY_DUPLEX) are overridden. 0: Auto-Negotiation disabled 1: Auto-Negotiation enabled	R/W
8	**Duplex Mode (PHY_DUPLEX)** This bit is used to set the duplex when the Auto-Negotiation Enable (PHY_AN) bit is disabled. 0: Half Duplex 1: Full Duplex	R/W

HP AUTO-MDIX

HP Auto-MDIX facilitates the use of CAT-3 (10BASE-T) or CAT-5 (100BASE-TX) media UTP interconnect cable without consideration of the interface wiring scheme. If a user plugs in either a direct connect LAN cable or a cross-over patch cable, the transceiver is capable of configuring the TXPx/TXNx and RXPx/RXNx twisted pair pins for correct transceiver operation.

The internal logic of the device detects the TX and RX pins of the connecting device. Since the RX and TX line pairs are interchangeable, special PCB design considerations are needed to accommodate the symmetrical magnetics and termination of an Auto-MDIX design. For transformerless applications, it is recommended to disable HP Auto-MDIX. Refer to the specific Microchip device datasheet for additional information.

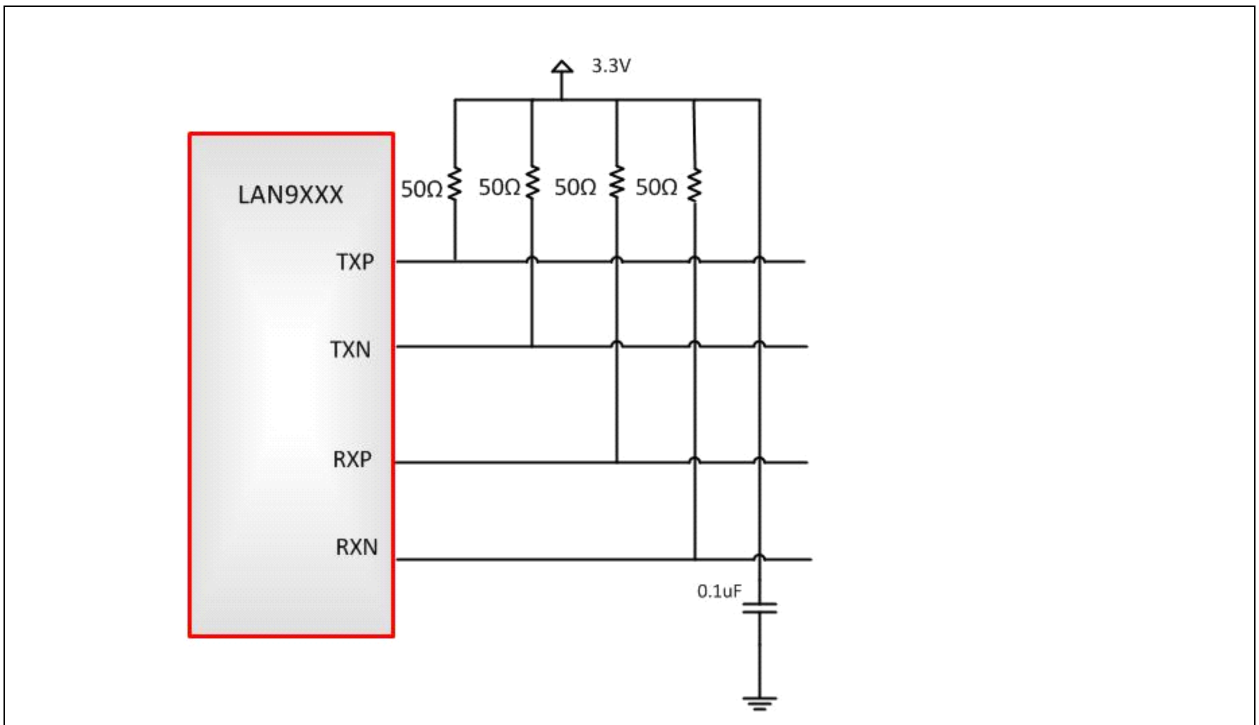
Note:	The HP Auto-MDIX feature may be useful if the TX and RX lines are accidentally swapped in the transformerless application.

PHYSICAL CONNECTION

The transmitter output is designed to sink current into a transformer. When the transformer is not used, load resistors must be connected at each device to develop the output voltage as shown in Figure 3.

Note:	*RX pins are configured with 50 Ohm to the supply for AMDIX operation where they may be configured as TX pins. If AMDIX is disabled and RX pins are for receive mode only, then the external termination can be tied any way possible as long as there is 100 Ohm differential across the pins.*

FIGURE 3: LOAD RESISTORS IN TRANSFORMERLESS APPLICATION

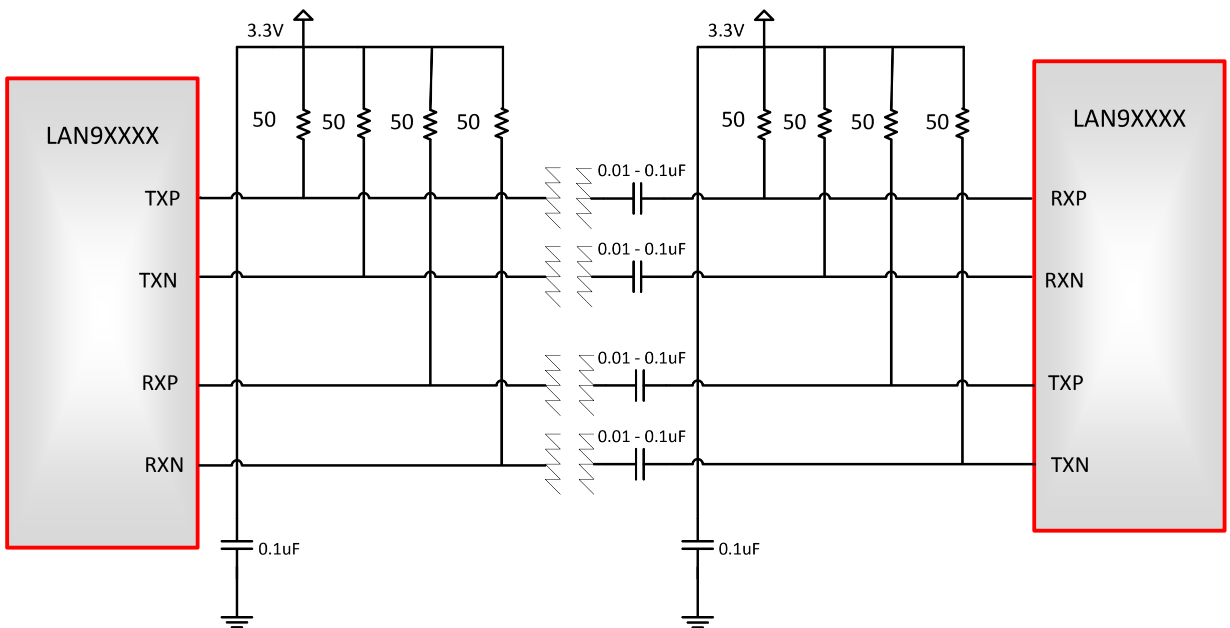


DISTANCE CONSIDERATIONS

Microchip recommends that both Ethernet devices have terminating resistors on each analog pin. Proper lab validation should be performed to provide optimum resistor placement using the configuration shown in Figure 4.

Cable connections over very long distances without transformers are not encouraged due to the risk for potential high voltage build-up and noise effects.

FIGURE 4: EXAMPLE CONNECTION



Note:	*50 Ohm termination at each device with no AC coupling capacitance can be used for PCB traces greater than 12”, assuming both Microchip devices are sharing the same power domain within the same PCB.*

Note:	*AC coupling capacitors in the range of 0.1uF to 0.01uF are recommended for any board to board communications using different power domains. Due to the possible shift in power/ground domains between boards, the coupling capacitor is required to minimize DC balancing issues.*

SUMMARY

Microchip Ethernet devices may be configured in non-typical transformerless network applications to transmit and receive reliably. Recommendations include the use of non-polarized capacitors for DC isolation from a network cable, with a minimum DC isolation rating which suits the individual application.

APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00002190A (07-06-16)	All	Initial release.

ISBN: 9781522407195

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