
Transformerless Applications of Microchip's LAN9250/LAN935x Ethernet Controller and Switches

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INTRODUCTION

The Microchip LAN9250/LAN935x provides design solutions targeted to support next generation Ethernet switches and a 10/100 Industrial Ethernet MAC/PHY controller. The Ethernet switch products are divided into host bus and MII categories with the host bus version supporting a full featured Ethernet MAC residing behind the switch fabric. The non-host bus versions support various MII, RMII and Turbo MII options with 1 and 2 port options.

The following table lists the various products available.

Part Number	Description
LAN9250	10/100 Industrial Ethernet Controller & PHY
LAN9352	2-Port 10/100 Managed Ethernet Switch with 16-Bit Non-PCI CPU Interface
LAN9353	3-Port 10/100 Managed Ethernet Switch with Single MII/Turbo MII or Dual RMII
LAN9354	3-Port 10/100 Managed Ethernet Switch with Single RMII
LAN9355	3-Port 10/100 Managed Ethernet Switch with Dual MII/RMII/Turbo MII

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.

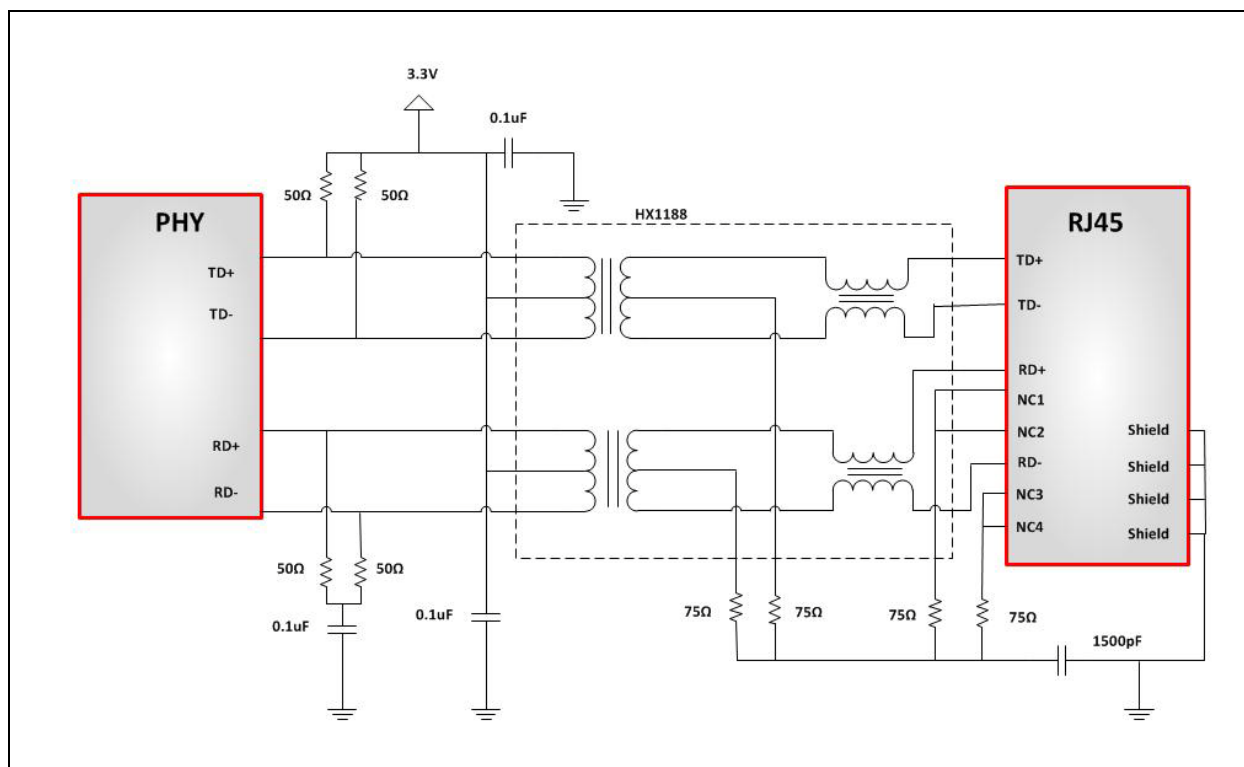
Note: For information on transformerless operation of the LAN9252, refer to the Transformerless Applications of Microchip's LAN9252 EtherCAT® Controller application note.

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

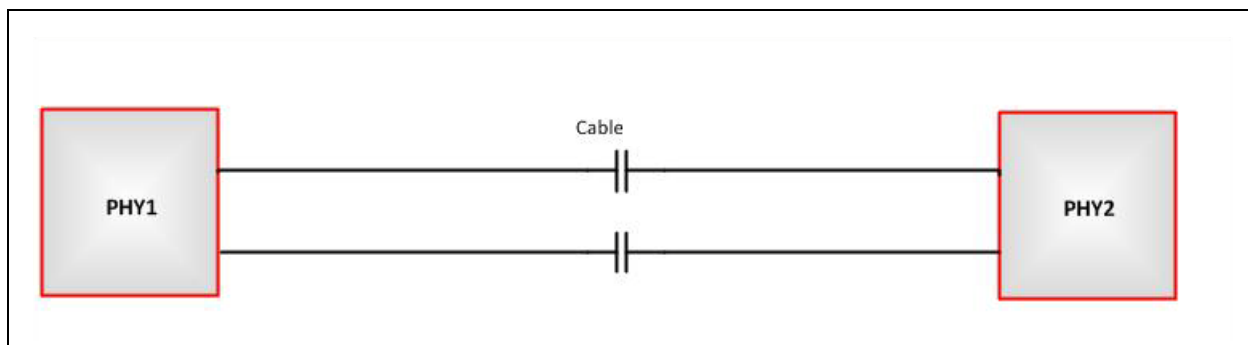
To meet the operational requirements of non-typical transformerless network applications, physical layer component transmit and receive separation and biasing as well as high voltage DC isolation to meet the specific safety requirements of the application must be implemented.

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.

The following methods can be used to disable Auto-Negotiation:

- [Disabling Auto-Negotiation via Registers](#)
- [Disabling Auto-Negotiation via Hardware Strapping](#)

Note: A lowercase "x" has been appended to the end of each PHY register name in the following sections, where "x" should be replaced with "A" or "B" for the PHY A or PHY B registers respectively. In some instances, a "1" or a "2" may be appropriate instead.

Disabling Auto-Negotiation via Registers

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

PHY x Basic Control Register (PHY_BASIC_CONTROL_x)			
Bits	Description	Type	Default
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	1'b1 when in 100BASE-FX mode else 1'b1 when autoneg_strap_X is '1' else defaults to speed_strap_x value
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	1'b0 when in 100BASE-FX mode else defaults to autoneg_strap_X value
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	duplex_strap_x value when in 100BASE-FX mode else 1'b0 when autoneg_strap_X is '1' else defaults to duplex_strap_x value.

Disabling Auto-Negotiation via Hardware Strapping

For LAN9250, autoneg_strap_2, duplex_strap_2 and speed_strap_2 are not valid.

Strap Name	Description	Pin/Default Value
autoneg_strap_1	PHY A Auto Negotiation Enable Strap: '0' -- Disable Auto negotiation '1' -- Enable Auto negotiation	LAN9250,LAN9352,LAN9354 : 1'b1 LAN9353,LAN9355 : P1_INTPHY strap value (Note: P1_INTPHY is a hard strap latched during reset)
autoneg_strap_2	PHY B Auto Negotiation Enable Strap: '0' -- Disable Auto negotiation '1' -- Enable Auto negotiation	1'b1
duplex_strap_1/2	PHY x duplex select strap : '1' -- full duplex '0' -- Half duplex	1'b1
speed_strap_1/2	PHY x speed select strap '1' -- 100Mbps '0' -- 10Mbps	1'b1

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 (for LAN9250 only single TXP/TXN, RXP/RXN) 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.

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

Note: A lowercase "x" has been appended to the end of each PHY register name in the following sections, where "x" should be replaced with "A" or "B" for the PHY A or PHY B registers respectively. In some instances, a "1" or a "2" may be appropriate instead.

Disabling Auto-MDIX via Registers

Software based control of the Auto-MDIX function may be performed using the Auto-MDIX Control (AMDIXCTRL) bit of the PHY x Special Control/Status Indication Register (PHY_SPECIAL_CONTROL_STAT_IND_x). When AMDIXCTRL is set to 1, the Auto-MDIX capability is determined by the Auto-MDIX Enable (AMDIXEN) and Auto-MDIX State (AMDIXSTATE) bits of the PHY x Special Control/Status Indication Register (PHY_SPECIAL_CONTROL_STAT_IND_x).

PHY x Special Control/Status Indication Register (PHY_SPECIAL_CONTROL_STAT_IND_x)			
Bits	Description	Type	Default
15	<u>Auto-MDIX Control (AMDIXCTRL)</u> This bit is responsible for determining the source of Auto-MDIX control. When set, Auto-MDIX functions are controlled using the AMDIXEN and AMDIXSTATE bits of this register. 0: Port x Auto-MDIX determined by strap inputs 1: Port x Auto-MDIX determined by bits 14 and 13	R/W NASR	0
14	<u>Auto-MDIX Enable (AMDIXEN)</u> When the AMDIXCTRL bit of this register is set, this bit is used in conjunction with the AMDIXSTATE bit to control the Port x Auto-MDIX functionality.	R/W NASR	0
13	<u>Auto-MDIX State (AMDIXSTATE)</u> When the AMDIXCTRL bit of this register is set, this bit is used in conjunction with the AMDIXEN bit to control the Port x Auto-MDIX functionality.	R/W NASR	0

Auto-MDIX Enable	Auto-MDIX State	Mode
0	0	Manual mode, no crossover
0	1	Manual mode, crossover
1	0	Auto-MDIX mode
1	1	RESERVED (do not use this state)

Disabling Auto-MDIX via Hardware Strapping

MDIX Strap Functionality is defined as below.

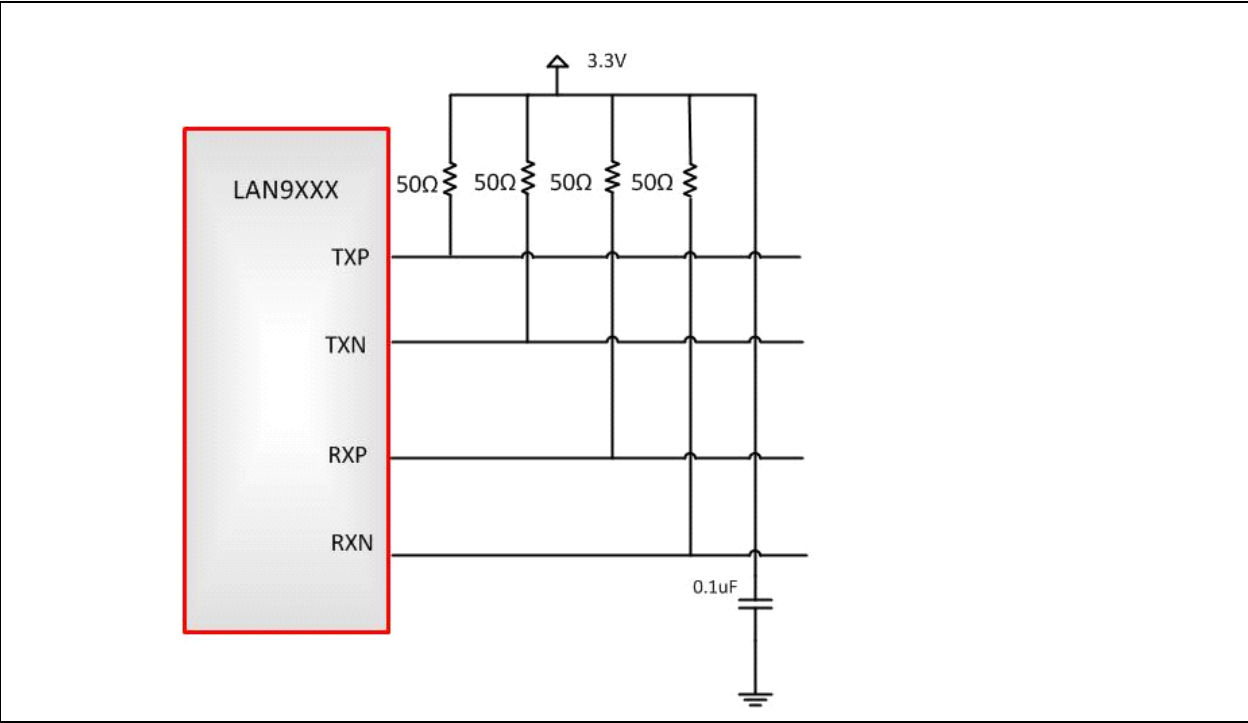
auto_mdix_strap_x	manual_mdix_strap_x	Mode
0	0	Manual mode, no crossover
0	1	Manual mode, crossover
1	X	Auto-MDIX mode

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

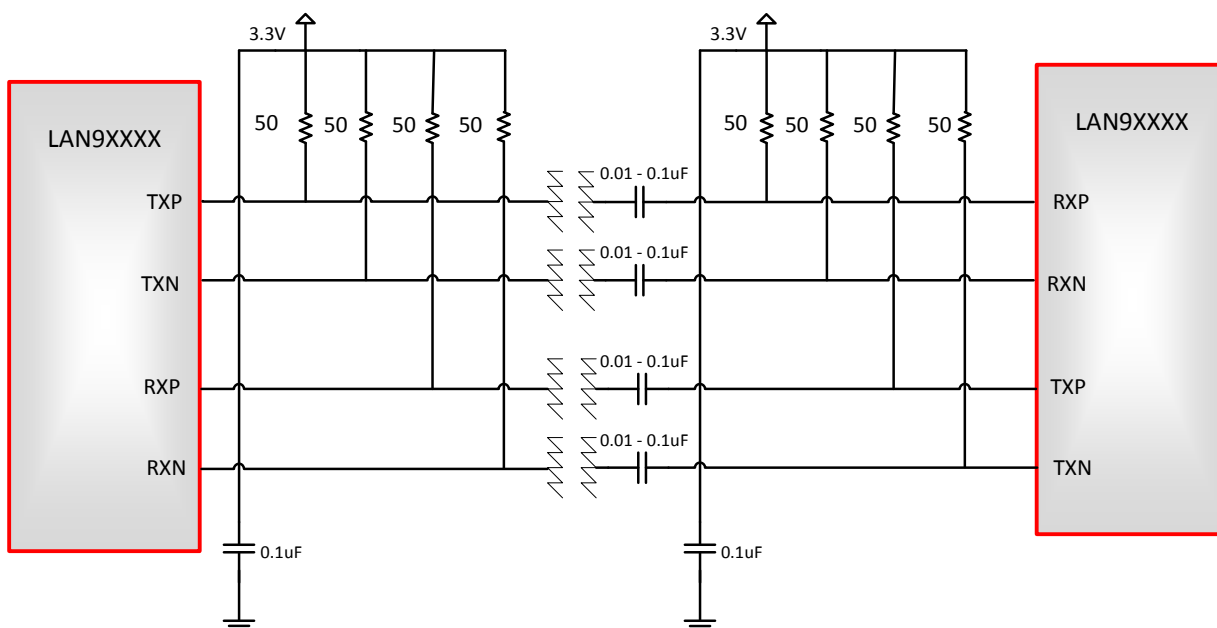


DISTANCE CONSIDERATIONS

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 are required 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
DS00001900B (06-14-16)	All	LAN9252 transformerless applications is now covered in a separate application note and is therefore removed from this application note.
	All	Removed “backplane” references.
	Transformerless Configuration	• Removed line from third paragraph: “(except LAN9252 where Auto-Negotiation and Auto-MDIX are always enabled)” • In third paragraph, changed “Auto-Negotiation and Auto-MDIX may...” to “Auto-Negotiation and Auto-MDIX must...” • Removed fourth paragraph.
	Auto-Negotiation	• Removed sentence: “LAN9XXX has been tested successfully for Auto-Negotiation with the configurations given in the hardware section below.” and replaced with information stating Auto-Negotiation must be disabled in transformerless applications. • In note, removed “(This is not applicable for LAN9250)”
	Disabling Auto-Negotiation via Registers	Removed text from title: “(not applicable for LAN9252, Auto- Negotiation always enabled)”
	HP Auto-MDIX	In note, removed “(This is not applicable for LAN9250)”
	Distance Considerations	Simplified section.
	Typical Transformer Isolation	Simplified section.
DS00001900A (02-26-15)	Document Release	

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