

AN-1509 PhyterDual Flexible Port Switching

ABSTRACT

Texas Instruments flexible port switching offers an unprecedented number of ways for system designers to develop solutions that address specific application needs with the minimum number of components. The combination of flexible assignment of data paths between ports and the ability to change these assignments dynamically allow one part to meet many different needs. In addition to this flexibility, Texas Instruments decades of experience providing high-quality, high-reliability Ethernet makes the PHYTER™ dual 10/100 Ethernet PHY a great choice for your applications.

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1 Executive Summary

Texas Instruments innovative port switching offers system developers a host of unique, customizable features to meet the needs for specific applications. This novel feature is available in TI's multi-port Ethernet chips, starting with the PHYTER dual 10/100 Ethernet physical layer transceiver (DP83849). The concept behind flexible port switching is to allow the system developer to configure each of the internal data paths independently. This approach offers significant advantages over other multi-port physical layer devices. In particular, the flexible assignment of the ports enables many options not available in multi-component physical layer designs, including media conversion, cable extension, and port mirroring.

This document serves two purposes:

- Provides example applications utilizing Texas Instruments innovative new technology
- Introduces the flexible port switching features incorporated in the PHYTER dual.

Product Applicability:

DP83849I

DP83849IF

1.1 Definitions

The following are definitions for common terms used in this document:

- **Port** - Denotes the physical (wire-side) interface, either Port A or Port B. In the PHYTER dual, ports are switched at their MAC interfaces.
- **RMII Mode** - This MAC interface mode, otherwise known as the Reduced Media Independent Interface, incorporates a 50 MHz common reference clock input to the PHY for both transmit and receive. The data interface is two bits wide.
- **Single Clock MII Mode** - This MAC interface mode incorporates a common 25 MHz reference clock input to the PHY for both transmit and receive instead of two independent outputs clocks. The data interface is four bits wide as in standard MII.

2 Overview

Flexible port switching allows the data path between the cable side ports and the MAC interfaces to be modified either at system development or dynamically via the controlling software. In a dual port device, this allows many different configurations to be developed to address the specific needs of various applications. Several configurations are introduced to give examples of applications in which this new technology can be used. These include cable extenders, media converters, snooping devices, ring topologies and more. Following these examples, an introduction to the implementation details is provided for the first family of devices from Texas Instruments that will support this capability, the PHYTER dual.

The base flexibility of this innovative design is shown in [Figure 1](#). The left hand side MAC connections represent the interface from the microcontroller, ASIC, SOC, and so forth to the PHY device. This interface can be MII, RMII, or single-clock MII. The right side of the diagram represents the MDI connectors that lead to either magnetics and an RJ-45 connector or a fiber transceiver. For simplicity, only the PHY device is shown; it is implicit that the additional components are necessary in a system design.

The internal data paths are then directed to the desired locations through a network of multiplexors. Each data path can be individually assigned. For instance, it is possible to have data that is transmitted from MAC A leading out through Port A or Port B or both. This assignment is done independently from the data path assignments from the other inputs at Port A, Port B, and MAC B.

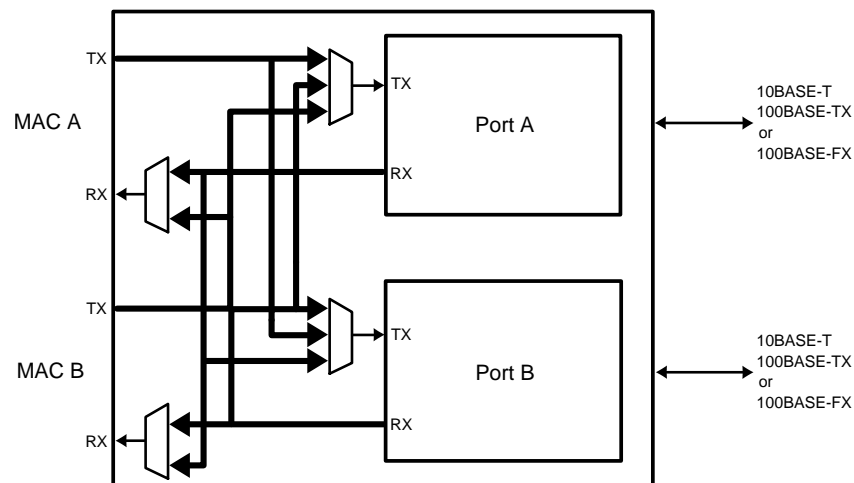


Figure 1. Port Switching

2.1 Normal Port Mapping

The default port configuration allows each PHY to act independently. This is shown in Figure 2, in which each port's transmitter and receiver are mapped straight to their corresponding MAC interfaces.

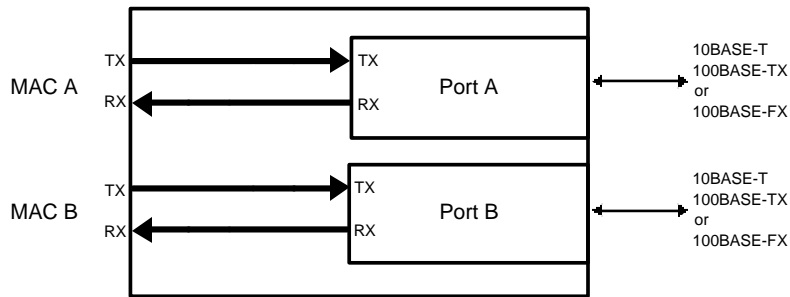


Figure 2. Normal Port Mapping

2.2 Port SWAP

In port Swap mode, each MAC interface is mapped to the opposite port. An example that takes advantage of the ability to switch both ports would be when the cables are connected incorrectly or the role of the attached networks are changed such that the cable connections need to be swapped. As shown in Figure 3, the connections can be changed within the PHYTER dual instead of physically swapping the cables. This dynamic port configuration can be handled by the software.

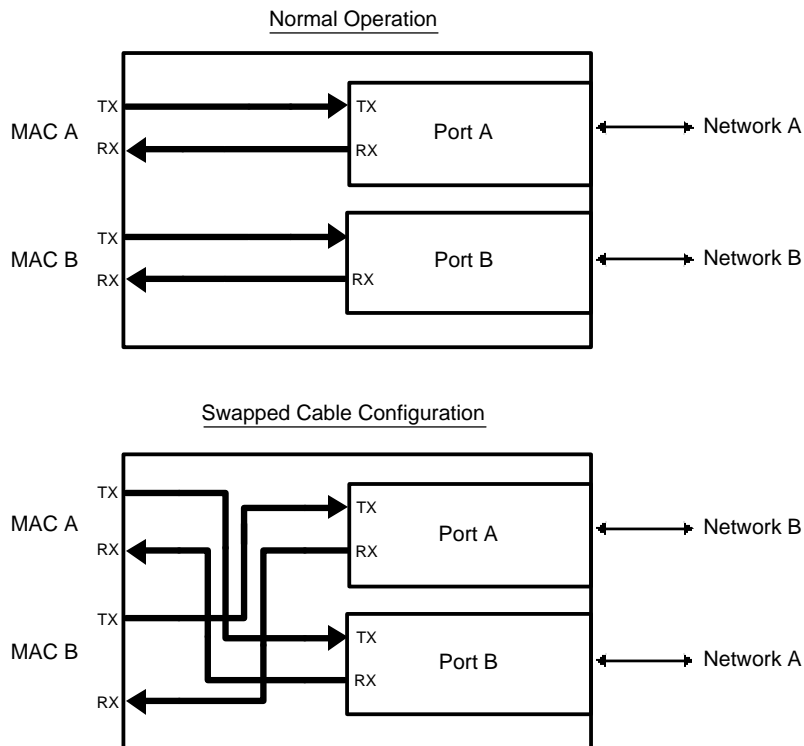


Figure 3. Cable Swap

Port swap mode could be used as part of a software-assisted failover from one link to another. When failure is detected on the primary port, the data traffic is swapped to the secondary port, as shown in Figure 4.

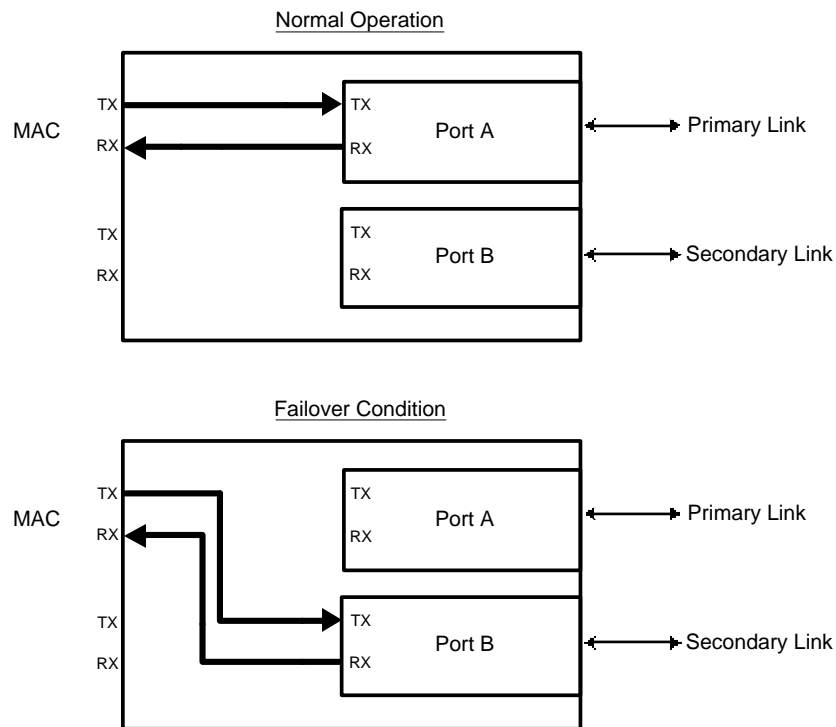


Figure 4. Software-Assisted Failover

An extension of software-assisted failover allows the PHYTER dual to act as a single physical layer with dedicated fiber and copper ports, as shown in Figure 5. In the example, the primary network is copper, and the secondary is fiber.

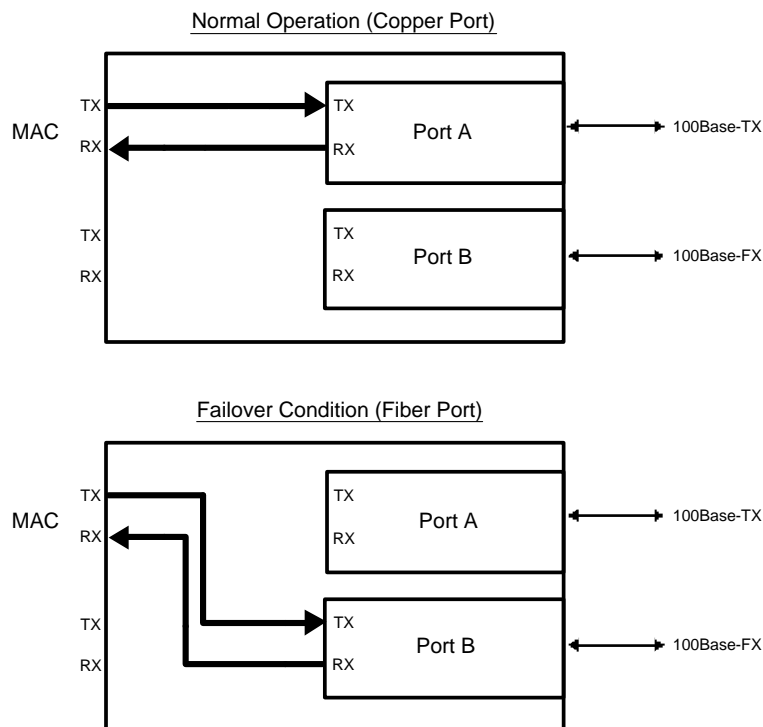


Figure 5. Single with Dedicated Copper and Fiber Ports

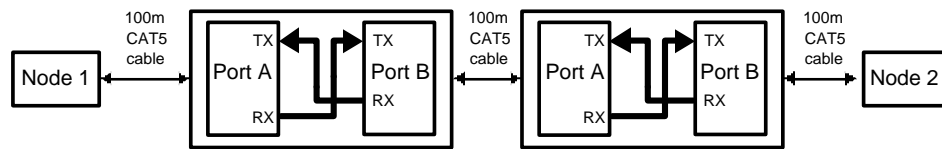
Notes and Restrictions

Since both ports are operating independently, there are no restrictions on speed or duplex configuration for either port. However, the MAC interfaces must share a common RMI setting. In other words, both MAC interfaces must be configured to use RMII, or both must be configured to use MII.

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

2.3 Cable Extender

In extender mode, shown in [Figure 6](#), the PHYTER dual allows the installation of longer cable installations than the normal standards without the intervention of a switch. In copper mode, a single PHYTER dual can be used to extend a 100-meter cable to 200 meters. In fiber mode, a PHYTER dual can be used to extend a 1-kilometer cable to 2 kilometers. Extender mode functions in 10Mb/s copper mode or 100Mb/s copper or fiber modes and requires the connection and each end node to operate at the same speed; the speed configuration is accomplished via autonegotiation straps for copper and automatically for fiber. In copper mode, extender mode can be used with power over Ethernet to provide a simple cable extending solution without the need for a power source in the middle of the cable installation.



Note: MAC interfaces are unused in the intervening devices.

Figure 6. Extender Example (300 meters copper)

2.4 Media Converter

Media converter mode, shown in [Figure 7](#), allows conversion of copper to fiber and vice-versa at 100Mb/s. This configuration allows longer run fiber to be used in situations where fiber support is not built into the end device. This configuration can also be combined with power over Ethernet on the copper side.

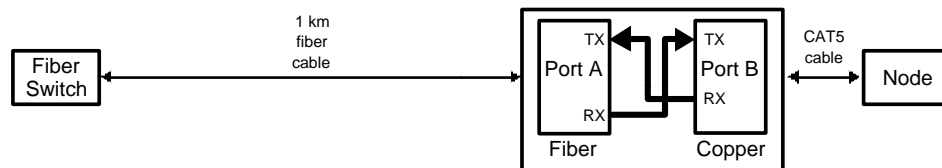


Figure 7. Media Converter Example

2.5 Ethernet Snoop Device

An Ethernet-based snoop device, shown in [Figure 8](#), can be created by combining the extender functionality with the normal port mapping. This configuration supports applications that require the attachment of a device into the line that will mirror received traffic for a third node to monitor. This configuration requires a pass-through from Port A to Port B (extender mode) and a straight path from the port of interest to the MAC RX interface. Only one direction of traffic can be seen at a time unless both MAC RX interfaces are employed.

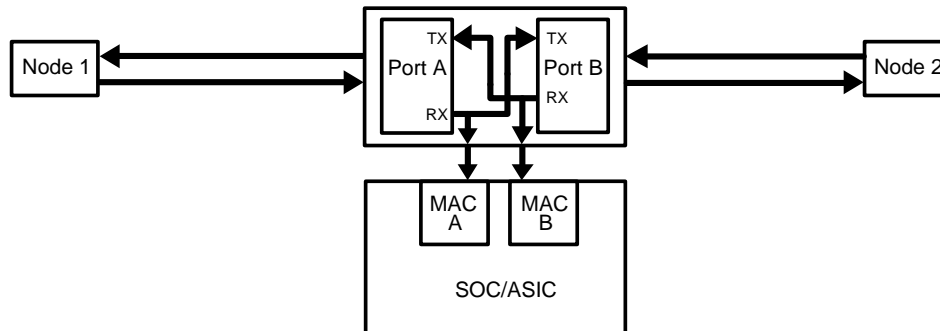


Figure 8. Ethernet Snoop Device

Notes and Restrictions

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

2.6 Ethernet Ring Network

Another potential configuration dynamically chooses between extender mode and normal mode to support an Ethernet-based ring topology. An example is shown in Figure 9. In a ring network where each node is given its own timeslice, the PHYTER dual can be controlled by software to deliver only the appropriate packets to the node, sending the bulk of the traffic to the next node. Simultaneous to the appropriate packet reception, an outgoing packet would be transmitted onto the ring network. This reduces the burden on the node processor.

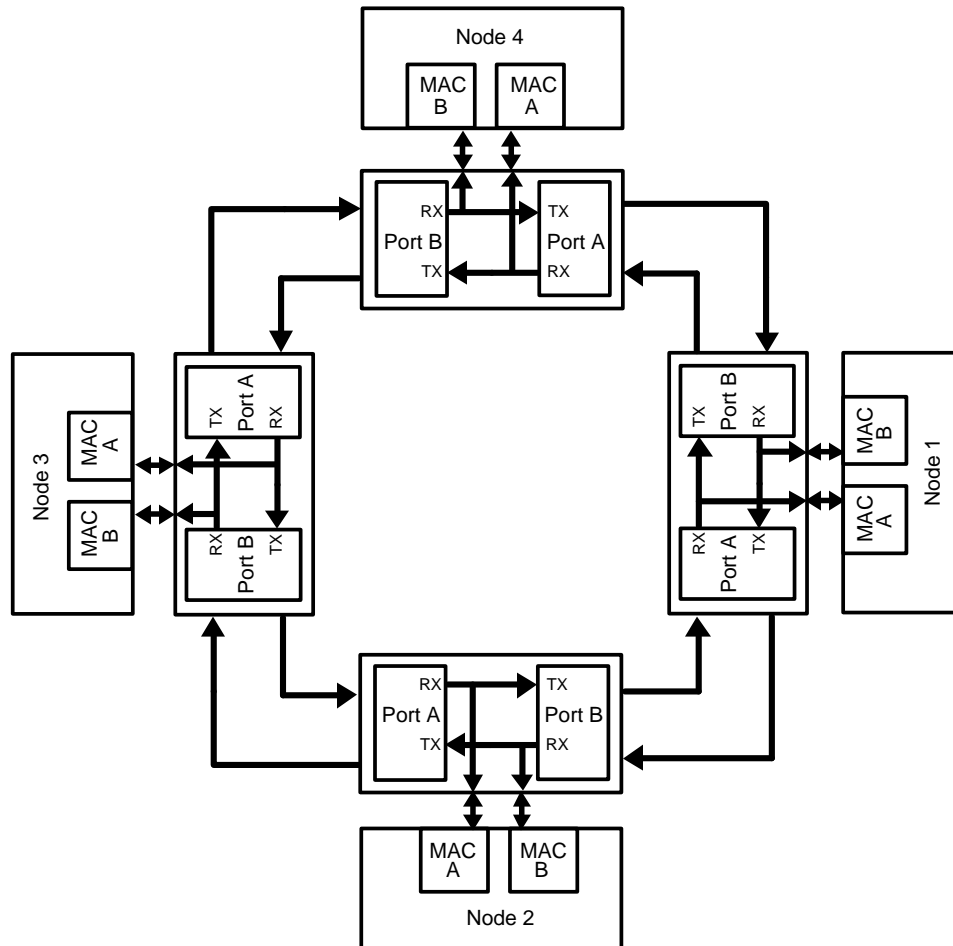


Figure 9. Ethernet Ring Example With 4 Nodes

Notes and Restrictions

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

2.7 BROADCAST TRANSMIT

Broadcast transmit mode, shown in [Figure 10](#) and [Figure 11](#), allows both ports to transmit from a single MAC.

NOTE: RX port assignment is independent and therefore is not shown.

Notes and Restrictions

To ensure synchronous operation, both ports must be in a common-clock mode, either RMI mode (RBR:RMI_EN = 1) or single clock TX MII mode (RBR:SCMII_TX = 1). Both ports must be operating at the same speed (10 or 100Mb). Both ports must be in full duplex mode to ensure no collisions are seen. This is because in single clock TX MII mode, a collision on one PHY port would cause both ports to send the Jam pattern from the single MAC.

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

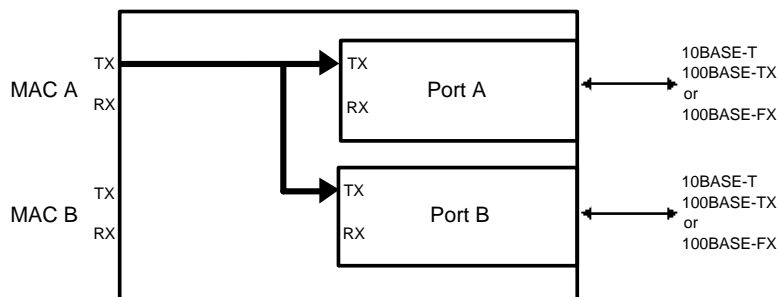


Figure 10. Broadcast TX MAC A

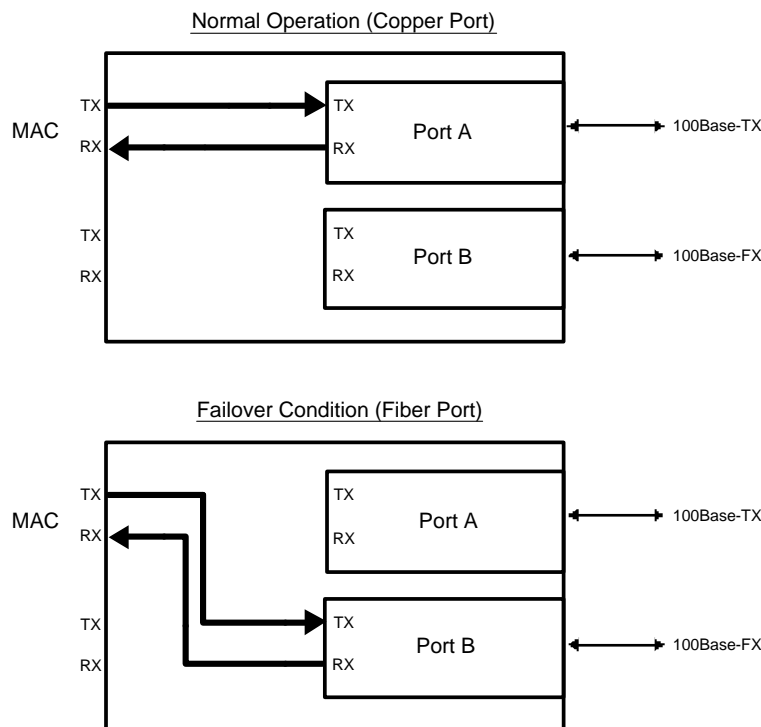


Figure 11. Broadcast TX MAC B

2.8 Dedicated Redundant Connections

In situations where redundancy is important, the PHYTER dual can be used with two channels running simultaneously for the fastest possible failover. An example is shown in Figure 12. The transmitting side of each node acts in broadcast mode. The receive side selects one port or the other based on link status via external control.

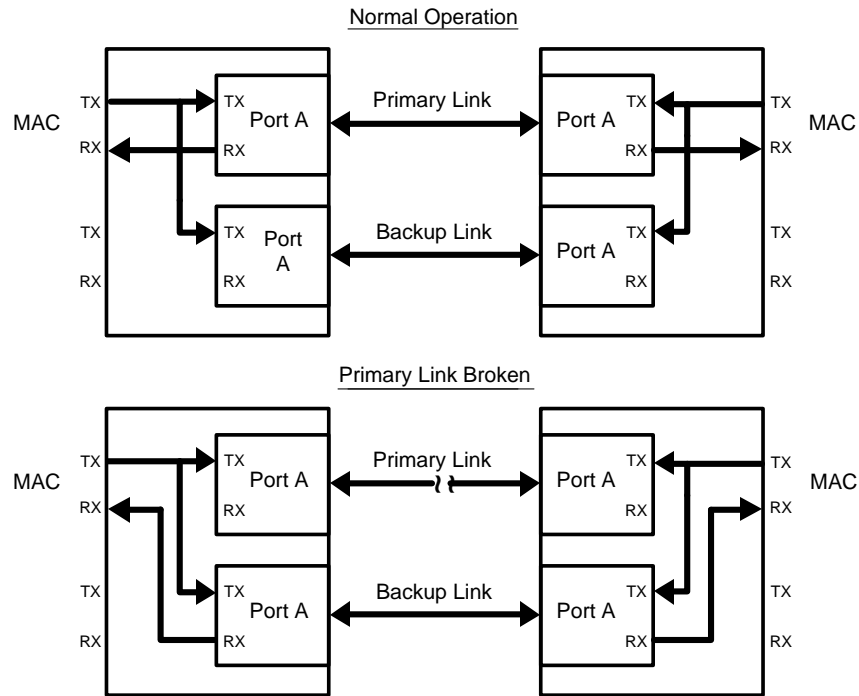


Figure 12. Dedicated Redundant Connections

Notes and Restrictions

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

2.9 Mirror Receive

In this mode, shown in [Figure 13](#) and [Figure 14](#), one port's receive data is reflected on both MAC interfaces.

NOTE: TX port assignment is independent and, therefore, is not shown.

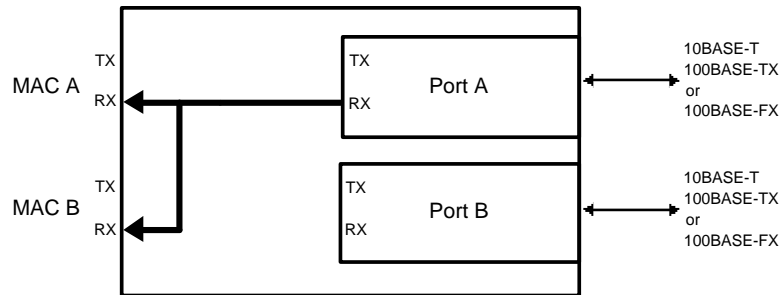


Figure 13. Mirror RX Port A

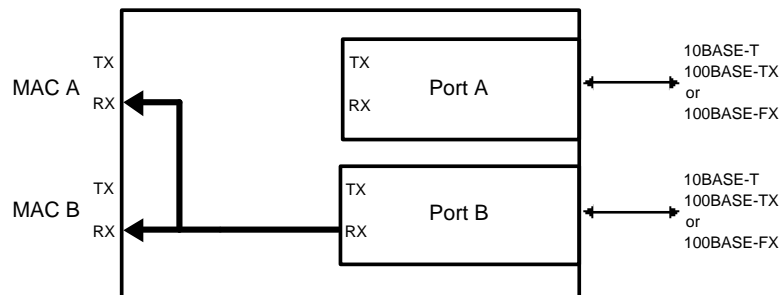


Figure 14. Mirror RX Port B

Notes and Restrictions

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

2.10 Port Disabled

Either or both MAC interfaces can be disabled, as shown in [Figure 15](#) and [Figure 16](#).

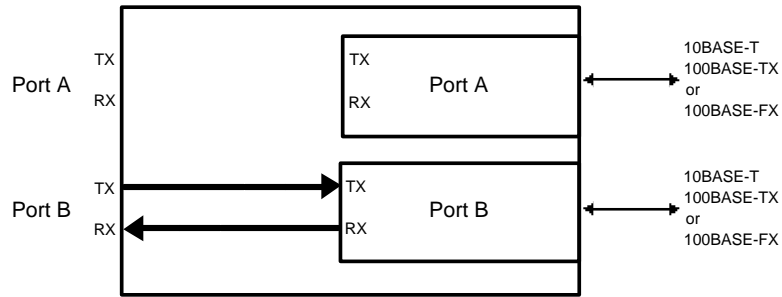


Figure 15. Port A Disabled

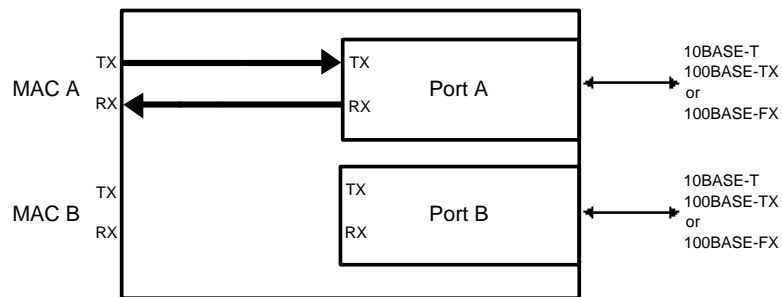


Figure 16. Port B Disabled

2.11 1 to 3 Unidirectional Repeater

More unusual applications can be created by combining modes of operation. For instance, in a situation where one node controls three other nodes, two PHYTER dual devices can be used together in different modes to form a 1 to 3 unidirectional repeater, as shown in Figure 17. Note that both PHYTER dual devices must be operating in RMII or single-clock MII mode. One PHYTER dual is in extender mode, while the other broadcasts TX MAC A data.

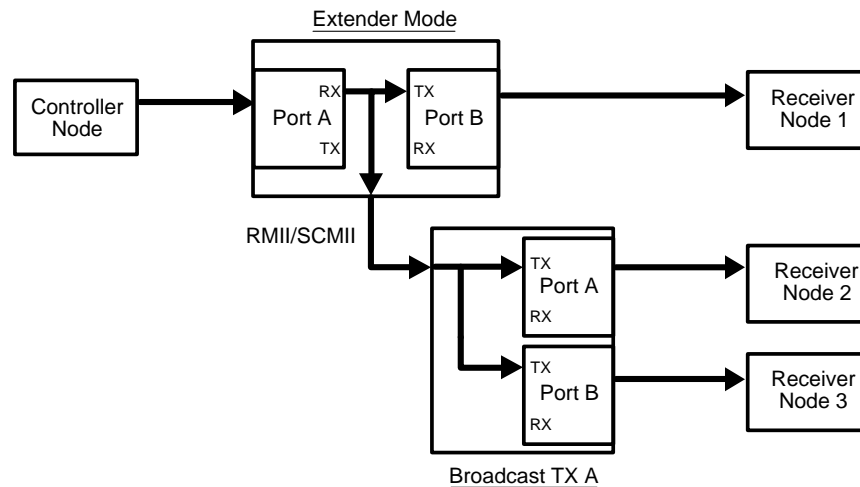


Figure 17. 1 to 3 Unidirectional Repeater

Notes and Restrictions

The use of energy detect and powerdown modes may produce unexpected results and, therefore, should not be enabled.

3 Implementing Flexible Port Switching

The PHYTER dual supports a flexible assignment scheme for each of the ports to the MII/RMII interface. Either of the MAC interfaces may be assigned to the physical ports A or B. These values are controlled by the RMII and Bypass Register (RBR). Transmit and receive assignments can be made separately to allow even more flexibility (both ports could transmit from MAC A while allowing separate receive paths for the ports).

In addition, the opposite receive port may be used as the transmit source for a port, enabling a cable extender or media converter. As shown in Figure 18, Port A receive data may be used as the Port B transmit data source while Port B receive data may be used as the Port A transmit data source. For proper clock synchronization, this function requires the device be in a common-clock mode, either RMII or single clock MII mode. A configuration strap is provided on the RXD_2_B pin to enable extender/media converter mode.

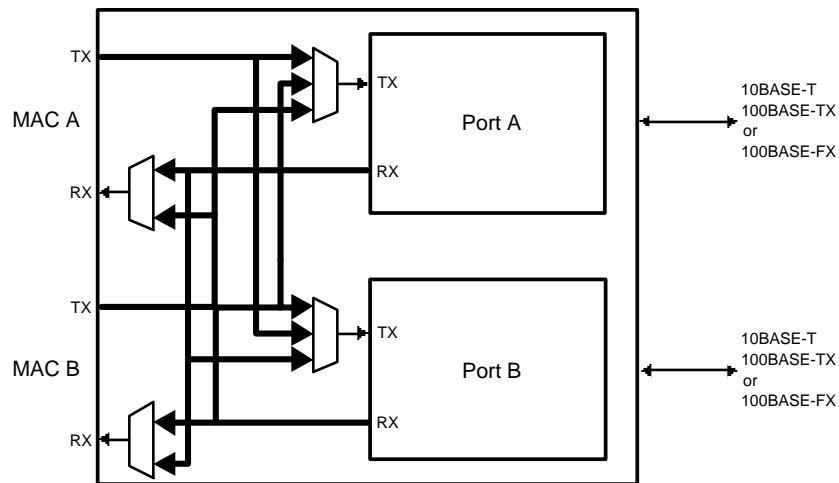


Figure 18. Port Switching

3.1 RX Port Mapping

RX Mapping controls and configurations are shown in [Table 1](#) and [Table 2](#).

Table 1. RX Mapping Controls

RBR[12:11]	Ports Desired RX MAC Destination
00	Normal
01	Opposite
10	Both
11	Disabled

Table 2. RX Port Mapping Configurations

Port A RBR[12:11]	Port B RBR[12:11]	RX MAC A Data Source	RX MAC B Data Source
0	0	Port A	Port B
0	1	Port A	Port B
0	10	Port A	Port B
0	11	Port A	Disabled
1	0	Port A	Port B
1	1	Port B	Port A
1	10	Port B	Port A
1	11	Disabled	Port A
10	0	Port A	Port B
10	1	Port B	Port A
10	10	Port A	Port B
10	11	Port A	Port A
11	0	Disabled	Port B
11	1	Port B	Disabled
11	10	Port B	Port B
11	11	Disabled	Disabled

Note that each port has ultimate control over the data appearing at its MAC interface. This means that in order for Port B to send data to MAC A, Port A must be configured to either send data to MAC B or be disabled; the reverse is also true.

Energy detect and powerdown modes should not be enabled if a MAC's receive data source is the opposite port.

3.2 TX Port Mapping

TX port mapping controls and configurations are shown in [Table 3](#) and [Table 4](#).

Table 3. TX Port Mapping Controls

RBR[10:9]	TX Port Data Source
00	Normal
01	Opposite
10	Opposite RX
11	Disabled

Table 4. TX Port Mapping Configurations

Port A RBR[10:9]	Port A TX Data Source	Port B RBR[10:9]	Port B TX Data Source
00	MAC A	00	MAC B
01	MAC B	01	MAC A
10	RX Port B	10	RX Port A
11	Disabled	11	Disabled

Energy detect and powerdown modes should not be enabled if a port's transmit data source is the opposite MAC.

3.3 Common Flexible Port Configurations

While there exist many combinations of the register settings, certain of these are considered to be more common. This section and its subsections provide detail on these common configurations, summarized in [Table 5](#).

Table 5. Common Flexible Port Configurations

Mode	Port A RBR[12:9]	Port B RBR[12:9]	Description
Normal	0	0	Port A assigned to Port A, Port B assigned to Port B
Full Port Swap	101	101	Port A assigned to Port B, Port B assigned to Port A
Extender/Media Converter (programmed with RX monitoring or strapped)	10	10	RX enabled, Port A transmits from Port B RX data, Port B transmits from Port A RX data
Extender/Media Converter (programmed with no RX monitoring)	1110	1110	RX disabled, Port A transmits from Port B RX data, Port B transmits from Port A RX data
Broadcast TX Port A	xx00	xx01	Both Ports transmit from TX MAC A
Broadcast TX Port B	xx01	xx00	Both Ports transmit from TX MAC B
Mirror RX Port A	10xx	11xx	Port A RX traffic appears on both Ports.
Mirror RX Port B	11xx	10xx	Port B RX traffic appears on both Ports.
Disable Port A	1111	xxxx	Port A is disabled
Disable Port B	xxxx	1111	Port B is disabled

Overall Notes and Restrictions

- **RMII Mode:** Both ports must have RMII mode enabled or disabled concurrently due to the internal reference clocking scheme.
- **10Base-T Serial Mode:** This MAC interface mode, also known as Serial network interface (SNI), may not be used when both ports share data connections (extender/media converter or broadcast TX MII port). This is due to the requirement of synchronous operation between ports, which is not supported in SNI mode.
- **CRS Assignment:** When a port is not in RMII mode, its associated CRS pin is sourced from the transmitter and controlled by the TX port assignment (RBR[10:9]). When a port is in RMII mode, the associated CRS pin is sourced from the receiver and controlled by the RX port assignment (RBR[12:11]).
- **LED Assignment:** LEDs are associated with their respective ports and, therefore, are not subject to remapping. For example, assertion of LED_LNK_A indicates valid link status for Port A independent of the port assignment.
- **Straps:** Strap pins are always associated with their respective port, (a strap on RX_ER_A is only ever used by Port A).
- **Port Isolate Mode:** Each port's isolate function (BMCR bit 10) is always associated with its respective port, (the isolate function for Port A is always controlled by Port A's BMCR). Due to the various possible combinations of TX and RX port selection, it may not be advisable to place a port in isolate mode.

- Energy Detect and Powerdown Modes: The output enables for each MII port are always controlled by the respective channel energy detect and powerdown functions. These functions should be disabled whenever an MII port is in use but not assigned to its default channel. Note that extender/media converter modes allow the use of energy detect and powerdown modes if the RX MII ports are not in use.

3.4 Extender/Media Converter Implementation

The PHYTER dual incorporates two methods of configuring extender/media converter mode: via a simple strap option or register control. Note that the definitions of extender and media converter only differ in their physical (copper or fiber) interfaces; the port swapping is the same. The optional use of RMII mode in conjunction with Extender/Media Converter mode allows flexibility in the system design.

Notes and Restrictions

Both ports must be operating at the same speed (10 or 100Mb). This can be accomplished using straps or port register controls. Both ports must be in full duplex mode. Both ports must use a common-clock mode, either RMII mode (RBR:RMII_EN = 1) or single clock MII mode (RBR:SCMII_RX = 1 and RBR:SCMII_TX = 1) to ensure synchronous operation. If single clock MII mode is used and only one RX to TX path is enabled, RBR:SCMII_RX in the RX port and RBR:SCMII_TX in the TX port must be set to 1. Media Conversion is only supported in 100Mb mode.

3.4.1 Strapped Extender or Media Converter Mode

The PHYTER dual provides a simple strap option to automatically configure both ports for extender or media converter mode, shown in [Figure 19](#), with no device register configuration necessary. The RXD_2_B/EXTENDER_EN strap is used in conjunction with two autonegotiation straps (LED_ACTCOL/AN_EN, LED_SPD/AN1), the RMII mode strap (RX_DV/MII_MODE), and the fiber mode (COL/FX_EN) strap to allow many possible configurations. If extender mode is strapped but RMII mode is not, both ports will automatically be configured for single clock MII receive and transmit modes. Note that in strapped extender/media converter mode, the RX MAC interfaces are still active, allowing easy monitoring of the data received on each port.

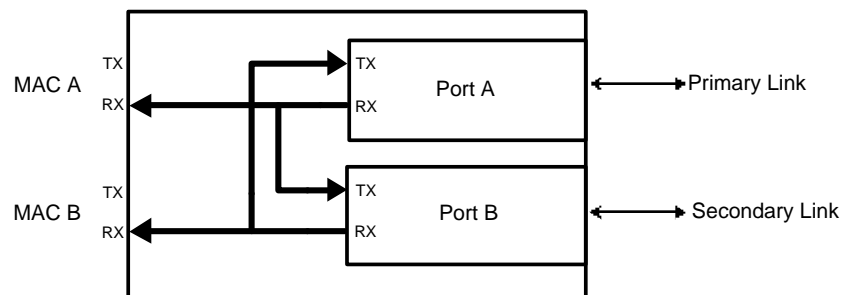


Figure 19. Extender/Media Converter (Strapped)

Several common configurations are shown in [Table 6](#). Note that either single-clock MII or RMII can be configured independently from the flexible port mode; it is required, however, that both ports must be configured to the same common-clock mode. Since the EXTENDER_EN strap forces full duplex mode (including autonegotiation advertisement), the AN0 (duplex) strap is not shown. If the receive MII ports are to be monitored, energy detect and powerdown modes should be disabled.

Table 6. Common Strapped Extender/Media Converter Mode Configurations

Mode	Autonegotiation Straps				Fiber Mode Straps		Notes
	AN_EN_A	AN1_A	AN_EN_B	AN1_B	FX_EN_A	FX_EN_B	
100Mb Copper Extender	1	1	1	1	0	0	Advertise 10/100Mb Full Duplex
	0	1	0	1	0	0	Force 100Mb Full Duplex
100Mb Fiber Extender	Don't care	Don't care	Don't care	Don't care	1	1	No Autonegotiation
10Mb Copper Extender	1	0	1	0	0	0	Advertise 10Mb Full Duplex
	0	0	0	0	0	0	Force 10Mb Full Duplex
100Mb Media Converter	Don't care	Don't care	1	1	1	0	Port A is Fiber, B is Copper with Autonegotiation
	1	1	Don't care	Don't care	0	1	Port A is Copper with Autonegotiation, B is Fiber
	Don't care	Don't care	0	1	1	0	Port A is Fiber, B is Copper Forced
	0	1	Don't care	Don't care	0	1	Port A is Copper Forced, B is Fiber

3.4.1.1 Programmed Extender or Media Converter Mode

Extender or media converter mode can also be programmed via register control. Figure 20 shows a common configuration, in which the RX MAC interfaces are not active; however, these interfaces can be activated by setting RBR[12:11] to 00.

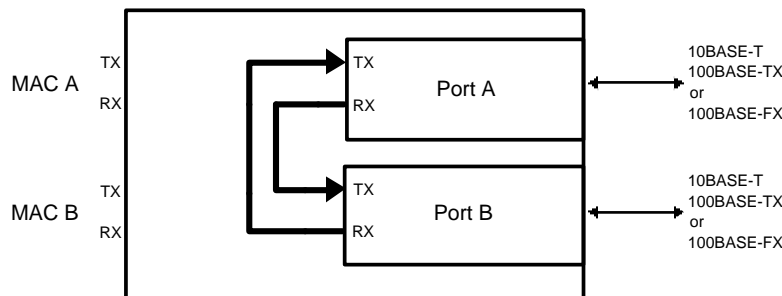


Figure 20. Extender/Media Converter (Programmed with no RX monitoring)

Several common configurations are shown in Table 7. Note that either single-clock MII or RMII can be configured independently from the flexible port mode; it is required, however, that both ports must be configured to the same common-clock mode. Software must ensure that both ports are in full duplex mode. If the receive MII ports are to be monitored, energy detect and powerdown modes should be disabled.

Table 7. Common Programmed Extender/Media Converter Mode Configurations

Mode	Autonegotiation Straps						Fiber Mode Straps		Notes
	AN_EN_A	AN1_A	AN0_A	AN_EN_B	AN1_B	AN0_B	FX_EN_A	FX_EN_B	
100Mb Copper Extender	1	1	1	1	1	1	0	0	Advertise 10/ 100Mb Full Duplex
	0	1	1	0	1	1	0	0	Force 100Mb Full Duplex
100Mb Fiber Extender	Don't care	Don't care	1	Don't care	Don't care	1	1	1	No Autonegotiation
10Mb Copper Extender	1	0	1	1	0	1	0	0	Advertise 10Mb Full Duplex
	0	0	1	0	0	1	0	0	Force 10Mb Full Duplex
100Mb Media Converter	Don't care	Don't care	1	1	1	1	1	0	Port A is Fiber, B is Copper with Autonegotiation
	1	1	1	Don't care	Don't care	1	0	1	Port A is Copper with Autonegotiation, B is Fiber
	Don't care	Don't care	1	0	1	1	1	0	Port A is Fiber, B is Copper Forced
	0	1	1	Don't care	Don't care	1	0	1	Port A is Copper Forced, B is Fiber

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