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Application Note
SimpliPHY ActiPHY Power Management

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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 1.1

In revision 1.1 of this document, the green Ethernet initiative was added. For more information, see [Define a Way to Save Lost Power](#).

1.2 Revision 1.0

Revision 1.0 was the first publication of this document.

2 SimpliPHY ActiPHY Power Management

This document describes the ActiPHY™ power management feature in Microsemi's SimpliPHY devices.

2.1 Saving Power on Unused PHY Ports

2.1.1 Inefficiency of Copper Ethernet PHYs

Copper Ethernet PHYs heavily dominate the wired LAN network topology because of their ease of use and cost effectiveness. One of the best advantages multi-speed copper Ethernet PHYs have over other physical layer devices is their ability to perform auto-negotiation between two linked PHYs to determine the fastest speed they can each attain to carry data traffic.

Auto-negotiation for copper PHYs is defined under IEEE 802.3, Clause 28. When a Clause 28-capable PHY is powered-up and active, it will start the auto-negotiation process to ascertain if it is connected to a link partner via a copper cable. Unfortunately, during this process, this means that the PHY is constantly powered-up and sending link pulses in order to be seen by the PHY on the other end of the cable. In a situation where the other PHY is physically not plugged into a cable, this PHY has no way of knowing that in this scenario, these link pulses are not being seen.

Consider an example of a laptop; an unplugged Ethernet connection still sending link pulses will further cause the battery to drain because the PHY is still trying to auto-negotiate even though there is no cable. In this situation, sending link pulses that will not be seen by another PHY when it is not plugged into a cable is, in essence, wasting power. The user could set the Ethernet port to be disabled, but then they will have to remember to manually enable it again when they plug in a cable.

Even more essential power saving can be reached on multi-port devices, especially Gigabit Ethernet switches. This fact has recently triggered a new green Ethernet initiative, one of whose goals is to decrease energy costs by reducing power consumption without sacrificing operational performance and functionality by recognizing when a port is active or inactive and adjusting its power consumption accordingly.

2.1.2 Define a Way to Save Lost Power

Auto-negotiation is a process where two PHYs exchange information about each other in order to best communicate. Knowing this, we can consider a way to potentially save power in the following scenarios:

- An unplugged PHY port (not connected to a cable)
- A PHY port, plugged into a cable with no link partner PHY on the other end
- A PHY port, plugged into a cable with a link partner PHY not transmitting link pulses because it is unpowered, in reset, or other reasons that prevent it from linking.

Examining each of these scenarios, one common theme realized is when the local PHY is unconnected or the link partner does not send link pulses, that this is an opportunity where the local PHY could try to reduce its transmission power by not sending link pulses. Transmission of link pulses that have to traverse across 100 meters of copper cable consumes a significant amount of power for a PHY. So, in essence, a decision circuit designed to detect link pulses and the absence of link pulses can trigger power savings.

The obvious way to save power is to disable the local transmit link pulses as well as the receiver. The problem is when you disable the receiver, the PHY cannot tell if a cable is later plugged in and if a link partner PHY then exists and is sending link pulses. Fully disabling the receiver would require some sort of external intervention to re-activate it. The second problem exists if you plug two power-saving PHYs together. If they both are disabled, how will they go back to normal power mode? What will be needed is a power savings feature that can realize the best time to save power, but still have reliability to re-engage an active link partner PHY when connected via a copper cable.

2.2 ActiPHY

ActiPHY was developed by Microsemi for their Gigabit Copper PHYs to save power in the scenarios described in Define a Way to Save Lost Power, page 2, and very well supports the abovementioned green Ethernet initiative.

This section will describe the methodology of this circuit in order to best save power and maintain reliability to link-up to link partner PHYs.

For this document, ActiPHY's feature will be described based on the VSC8658 Octal Gigabit Copper PHY, but it applies to all Microsemi Copper PHY devices including those integrated into a Layer 2 switch chip.

2.2.1 The Methodology

ActiPHY utilizes a signal-detect function that monitors the media interface for the presence of link pulses coming from a link partner PHY to determine when to automatically power-down the PHY. In order to prevent a situation where two ActiPHY-enabled PHYs are plugged into the same cable, the PHY will "wake up" at a programmable interval to send a small burst of link pulses to attempt to "wake-up" the link partner PHY. Once the local PHY receives link pulses, it will go back to normal operation which includes auto-negotiation and data traffic flow. The energy detect circuit will always be powered on in order to detect link pulses, however, the receiver data path will be disabled for power savings.

2.2.2 Resulting Power Savings

Referring to the VSC8641 datasheet that lists out power consumption for no link cases, ActiPHY enabled can save up to 70% power consumption on an unused port.

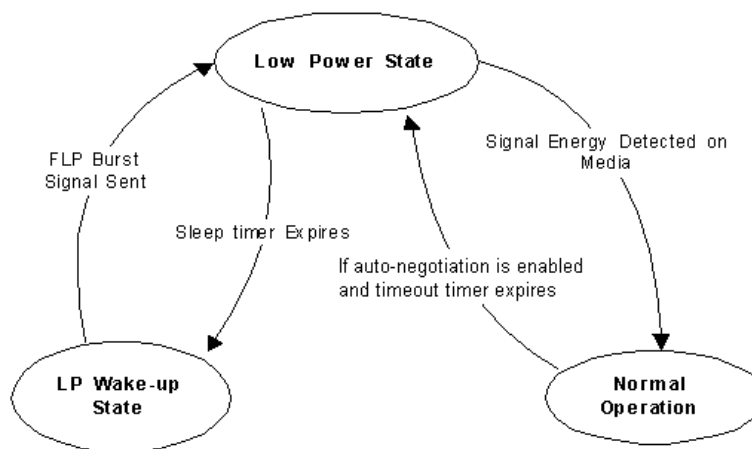
2.2.3 ActiPHY Power Management States

There are three operating states possible when ActiPHY mode is enabled:

- Low Power State
- LP Wake-Up State
- Normal Operating State

ActiPHY Power Management States

Figure 1 • ActiPHY Power Management States



ActiPHY can be configured on a per-port basis with Microsemi's multi-port copper Ethernet PHYs. The ActiPHY-enabled PHY switches between the low power state and LP wake-up state at a programmable rate (the default is two seconds) until signal energy has been detected on the media interface pins. When signal energy is detected, the PHY enters the normal operating state. If the PHY is in its normal operating state and the link fails, the PHY returns to the low power state after the expiration of the link status time-out timer. After reset, the PHY enters the low power state.

When auto-negotiation is enabled in the PHY, the ActiPHY state machine operates as described. If auto-negotiation is disabled and the link is forced to use 10BASET or 100BASETX modes while the PHY is in its low power state, the PHY continues to transition between the low power and LP wake-up states until signal energy is detected on the media pins. At that time, the PHY transitions to the normal operating state and stays in that state even when the link is dropped. If auto-negotiation is disabled while the PHY is in the normal operation state, the PHY stays in that state when the link is dropped and does not transition back to the low power state.

2.2.3.1 Low Power State

In the low power state, all major digital blocks are powered down. However, the following functionality is provided:

- SMI interface (MDC, MDIO, MDINT_n)
- CLKOUT

In this state, the PHY monitors the media interface pins for signal energy. The PHY comes out of low power state and transitions to the normal operating state when signal energy is detected on the media. In the absence of signal energy on the media pins, the PHY transitions from the low power state to the LP wake-up state periodically based on the programmable sleep timer (register bits 20E.14:13). The actual sleep duration is randomized from –80 milliseconds (ms) to +60 ms to avoid two linked PHYs in ActiPHY mode entering a potential lock-up state during operation.

2.2.3.2 Link Partner Wake-up State

In this state, the PHY attempts to wake up the link partner. Up to three complete fast link pulses (FLP) bursts are sent on alternating pairs A and B (assuming Auto MDI/MDI-X is enabled) on the copper media for a duration based on the wake-up timer, which is set using register bits 20E.12:11.

In this state, the following functionality is provided:

- SMI interface (MDC, MDIO, MDINT_n)
- CLKOUT

After sending signal energy on the relevant media, the PHY returns to the low power state.

2.2.3.3 Normal Operating State

In this state, the PHY establishes a link with a link partner. When the media is unplugged or the link partner is powered down, the PHY waits for the duration of the programmable link status time-out timer, which is set using register bit 28.7 and bit 28.2. It then enters the low power state.

2.2.3.4 Using ActiPHY for Fiber Media

ActiPHY is also supported on SimpliPHY devices with a fiber media port. The main difference between the copper media operation and fiber is the wake-up state will transmit a base page of all zeros (Clause 37 restart signal) for 30 ms.

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