Application Note 124

PHY Speed and Duplex Configuration

Micrel 10/100 Switches/PHYs

Introduction

The Fast Ethernet speed and duplex configuration process is often taken for granted. Most of the time when an Ethernet cable is connected between two Ethernet devices, a link is automatically established with matching speed and duplex settings. However, if there is a mismatch with either or both of these settings, the result is either no link or poor network performance. An understanding of the speed and duplex detection mechanisms will help to resolve these setting conflicts.

This application note provides a quick overview of how speed and duplex settings are determined and configured for Fast Ethernet devices. First, a brief introduction to some key configuration components, auto negotiation, parallel detection, and force mode, will be presented. A discussion of configuration modes will follow. And last, link results for all combinations of configuration modes between two Ethernet devices will be provided.

All Micrel Fast Ethernet PHYs and switches with integrated PHYs support auto negotiation and parallel detection. In addition, all of these devices, except for the KS8997, support force mode.

Configuration Components

Fast Ethernet speed and duplex configurations are determined using three key components: auto negotiation, parallel detection, and force mode.

Auto Negotiation

The auto-negotiation protocol, defined in section 28 of the IEEE 802.3u specification, allows two Ethernet devices to exchange information about their capabilities over a link segment. Speed and duplex capabilities are two parameters conveyed using the protocol.

An Ethernet device advertises its speed and duplex capabilities to its link partner using Fast Link Pulse (FLP) signals. FLPs are bursts of Normal Link Pulse (NLP) signals. A NLP is used for link detection in 10BASE-T systems, and is shown in Figure 1.

The protocol enables an Ethernet device and its link partner to select the highest priority setting among their common capabilities.

All of Micrel's Fast Ethernet Switches/PHYs support and advertise the following speed and duplex capabilities, listed from highest priority to lowest priority:

- 100BASE-TX / Full Duplex
- 100BASE-TX / Half Duplex
- 10BASE-T / Full Duplex
- 10BASE-T / Half Duplex

If there is no common capability detected at either end of the link, then no link will be made.

Detail information on the auto-negotiation process can be found in the IEEE 802.3u specification, in Ethernet textbooks, and at network technology and equipment vendors' websites.

Parallel Detection

The parallel detection mechanism operates on the PHY's receive side and works in conjunction with the auto-negotiation protocol to determine the speed of link partners that do not support auto negotiation. Speed detection is achieved by listening for the following characteristic signals:

- Normal Link Pulse signals
- 100BASE-TX Idle Pattern

NLP signals indicate the link partner is in 10BASE-T mode, and hence the local Ethernet device will set its port to 10BASE-T mode and establish link accordingly. Figure 1 shows the NLP waveform, which is measured differentially across a 100Ω termination at the near end.

The presence of 100BASE-TX Idle Pattern indicates the link partner is in 100BASE-TX mode, and hence the local Ethernet device will set its port to 100BASE-TX mode and establish link accordingly. Figure 2 shows the 100BASE-TX Idle Pattern waveform, which is measured differentially across a 100Ω termination at the near end.

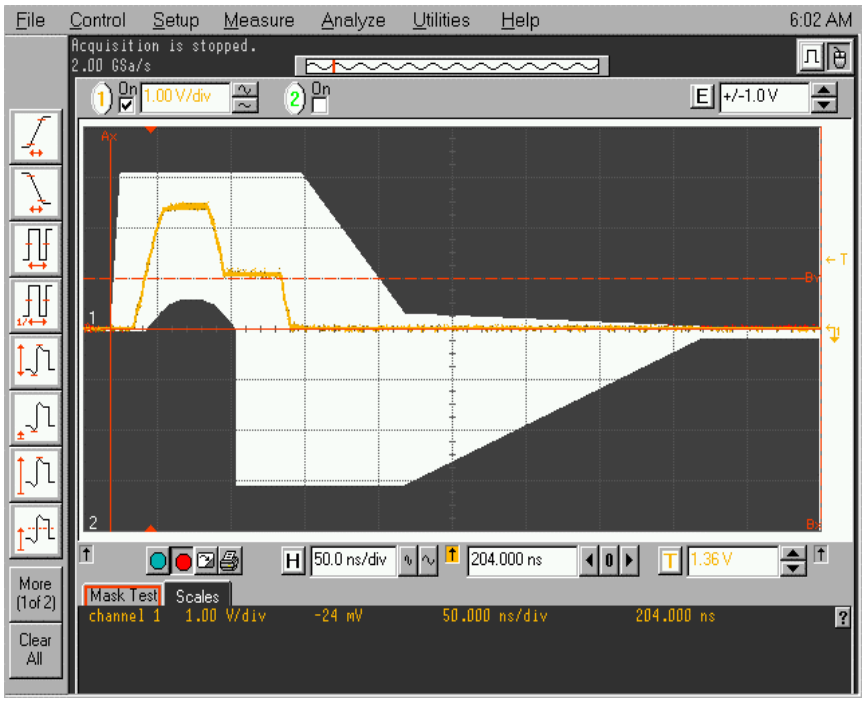

Figure 1. Normal Link Pulse

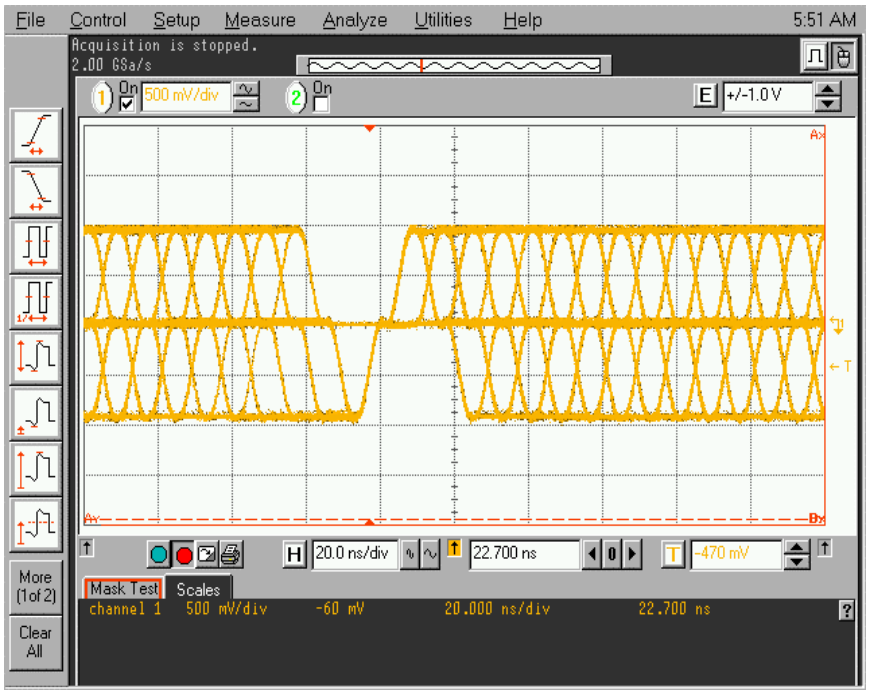

Figure 2. 100BASE-TX Idle Pattern

Parallel detection is limited to identifying only the speed of link partners that do not support auto negotiation. If a non-negotiating, fixed speed link partner is set to full duplex mode, the local auto-negotiating Ethernet device will be unable to obtain its link partner's duplex setting. Here, the IEEE specification calls for the auto-negotiating device to set its port to half duplex mode. The duplex mismatch that results from this scenario will produce frame errors, late collisions, and dropped frames. All of which can have a severe impact on network performance.

The auto negotiation and parallel detection process flow is depicted in Figure 3.

Force Mode

Force mode, also referred to as manual configuration, provides the option to set the speed and duplex mode of operation manually to a pre-determined configuration. This can be beneficial for those applications that require the bandwidth to be limited to a maximum of 10Mbps, or maintained at 100Mbps. Here, force mode is used to prevent a link partner from linking with the local Ethernet device if there is a speed difference.

All Micrel Fast Ethernet PHYs and Switches support force mode, except the KS8997. Force mode is enabled by disabling auto negotiation and selecting the desired speed and duplex mode of operation. Depending on the device, force mode can be configured through strapping pins or via registers. Registers are accessed using an EEPROM or one of the management interfaces. More details on the programming options can be found in each device's datasheet.

Configuration Modes

A local device and its link partner can each be set to either auto-negotiation (AN) mode or force mode. Over a link segment, this produces three different combinations of configuration modes: AN-AN, AN-force, and force-force.

AN-AN

In this mode, both the local device and its link partner are configured as auto-negotiating devices. FLPs are used to convey each device's speed and duplex capabilities to the other. Link will be set to the highest priority setting among their common capabilities. If there is no common capability between the two devices, no link will be made.

AN-Force

In this mode, the local device and its link partner are each configured to different configuration modes. One is in AN mode, while the other is in force mode. Due to the configuration mode differences, auto negotiation will fail and parallel detection will be used to detect the speed of the non-negotiating device. The auto-negotiating device will link at the speed of the non-negotiating device, and set its port to half duplex mode, as required by the IEEE specification. If the non-negotiating device is set to full duplex mode, there will be a mismatch in duplex setting. As a result, network performance will be impacted severely.

Force-Force

In this mode, both the local device and its link partner have their speed and duplex modes configured manually to pre-determined settings. Link is established if both devices are set to the same speed. If there is a mismatch in duplex setting between the devices, network performance will be impacted severely. Therefore, for proper operation, the speed and duplex settings need to be the same for both devices.

Link Results

The three matrices in Figures 4 through 6 depict the link results for all combinations of auto-negotiated and force mode settings between a local Ethernet device and its link partner.

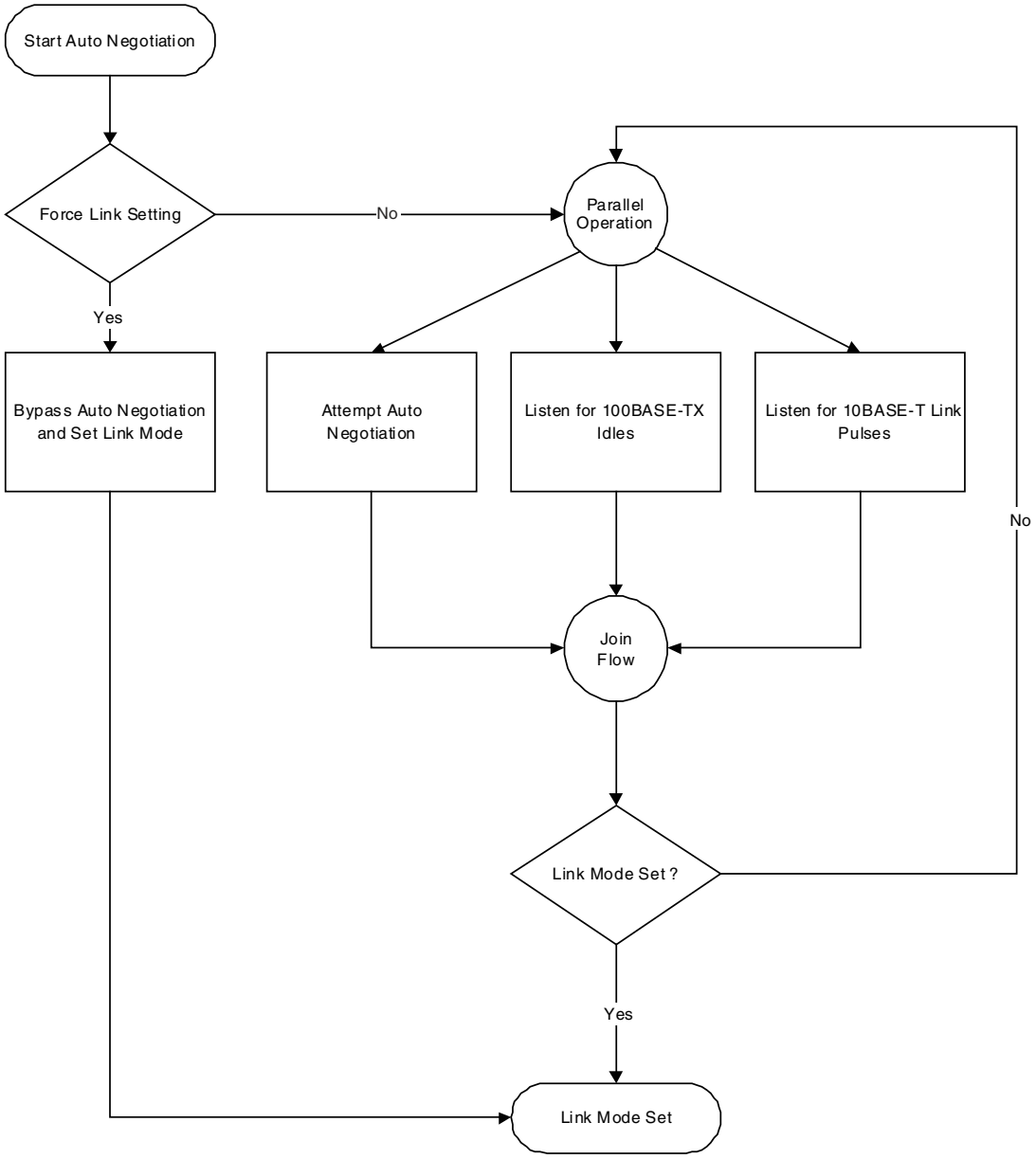

Figure 3. Auto Negotiation and Parallel Operation

Local Device (LD) \ Link Partner (LP)		**Auto-Negotiation Mode** **Advertise** **100BASE-TX / Full Duplex** **100BASE-TX / Half Duplex** **10BASE-T / Full Duplex** **10BASE-T / Half Duplex** **If auto negotiation fails, force to Half Duplex mode.**
Auto-Negotiation Mode	**Advertise** **100BASE-TX / Full Duplex** **100BASE-TX / Half Duplex** **10BASE-T / Full Duplex** **10BASE-T / Half Duplex** **If auto negotiation fails, force to Half Duplex mode**	Link Status (highest common capability between LD and LP) Speed: 100BASE-TX Duplex: Full Duplex
Force Mode	**100BASE-TX / Full Duplex**	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: LD is forced to Full Duplex LP is forced to Half Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.
	100BASE-TX / Half Duplex	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)
	10BASE-T / Full Duplex	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: LD is forced to Full Duplex LP is forced to Half Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.
	10BASE-T / Half Duplex	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)

Figure 4. Link Status (LD with LP in Auto-Negotiation Mode)

Link Partner (LP) / Local Device (LD)		Force Mode	
		100BASE-TX / Full Duplex	**100BASE-TX / Half Duplex**
Auto-Negotiation Mode	**Advertise** **100BASE-TX / Full Duplex** **100BASE-TX / Half Duplex** **10BASE-T / Full Duplex** **10BASE-T / Half Duplex** **If auto negotiation fails, force to Half Duplex mode**	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: LD is forced to Half Duplex LP is forced to Full Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)
Force Mode	**100BASE-TX / Full Duplex**	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: Full Duplex (forced setting for LD and LP)	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: LD is forced to Full Duplex LP is forced to Half Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.
	100BASE-TX / Half Duplex	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: LD is forced to Half Duplex LP is forced to Full Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.	Link Status Speed: 100BASE-TX (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)
	10BASE-T / Full Duplex	No Link	No Link
	10BASE-T / Half Duplex	No Link	No Link

Figure 5. Link Status (LD with LP in 100BASE-TX Mode)

Link Partner (LP) / Local Device (LD)		Force Mode	
		10BASE-T / Full Duplex	**10BASE-T / Half Duplex**
Auto-Negotiation Mode	**Advertise** **100BASE-TX / Full Duplex** **100BASE-TX / Half Duplex** **10BASE-T / Full Duplex** **10BASE-T / Half Duplex** **If auto negotiation fails, force to Half Duplex mode**	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: LD is forced to Half Duplex LP is forced to Full Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)
Force Mode	**100BASE-TX / Full Duplex**	No Link	No Link
	100BASE-TX / Half Duplex	No Link	No Link
	10BASE-T / Full Duplex	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: Full Duplex (forced setting for LD and LP)	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: LD is forced to Full Duplex LP is forced to Half Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.
	10BASE-T / Half Duplex	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: LD is forced to Half Duplex LP is forced to Full Duplex Mismatch in duplex will cause frame errors, late collisions and dropped frames.	Link Status Speed: 10BASE-T (determined by parallel detection) Duplex: Half Duplex (forced setting for LD and LP)

Figure 6. Link Status (LD with LP in 10BASE-T Mode)

Conclusion

The IEEE 802.3u specification provides the auto-negotiation protocol and parallel detection mechanism to facilitate the configuration of speed and duplex mode of operation for PHYs. Micrel's family of Fast Ethernet Switches/PHYs conforms fully to these standards.

With the many legacy hubs, switches, and network interface cards in the field that do not support auto negotiation, a configuration mismatch between an auto-negotiating device and a non-negotiating device is inevitable. By understanding how speed and duplex configurations are made and making use of the link result matrices in this application note, corrective action can be taken swiftly to resolve the mis-configuration.

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