AN2577

Getting Started with Gigabit Ethernet Switch Configuration Options

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INTRODUCTION

Microchip's family of gigabit Ethernet switches have powerful capabilities that may be enabled using various methods of configuration. Depending on the features needed in the network application, there are four primary methods to configure these switches. This application note describes available switch configuration methods and options with their associated trade-offs, allowing the developer to choose the best method for their application.

The following configuration options are available *(applicable Microchip parts)*:

- Configuration Straps *(KSZ9896C, KSZ9897R, KSZ9897S)*
- Microcontroller Configuration *(KSZ9897R, KSZ9897S)*
- Ethernet In-Band Access (IBA) Configuration *(KSZ9897R, KSZ9897S)*
- Host Processor Configuration *(KSZ8567R, KSZ9897R, KSZ9897S, KSZ9567R, KSZ9567S, KSZ9477S)*

TABLE 1: AVAILABLE CONFIGURATION METHODS PER FEATURE - REFERENCE TABLE

	Basic	Auto-Neg	EEE	VLAN	QoS	IEEE 1588 v2	802.1x Security	ACL	PME	WoL	AVB	DLR/HSR
Config. Strap	X	X										
8-bit MCU	X	X	X	X	X	X	X	X	X	X		
IBA	X	X	X	X	X			X				
Host Processor	X	X	X	X	X	X	X	X	X	X	X	X

Note: The user should take note of the difference between switch configuration mode and switch management mode. Switch management mode provides the added ability to send and receive Ethernet frames during normal operation. Switch configuration mode does not provide this ability.

CONFIGURATION STRAPS

The configuration strap option is a hardware method to configure the switch where pull-up or pull-down resistors are used to set the logic level high or low on strapping pins of the switch. For example, the KSZ9896C has several strapping pins with internal weak pull-up or pull-down resistors which allow the switch to operate in the unmanaged mode. A user can add 1KΩ to 10KΩ external pull-up resistors on non-LED pins, or 750Ω to 1KΩ pull-down resistors on LED strapping pins to override the effect of the weak internal resistors.

The strapping pins exhibit very high impedance when the device is in reset. They are internally sampled at the rising edge of the reset pin, RESET_N. Once the RESET_N pin is high, all of these pins become driven outputs.

The user must be aware that the internal pull-up/pull-down resistors are weak. Therefore, if the application board uses any external pull-up or pull-down resistors, care must be taken. If an external processor is connected with a switch, the processor should also be checked for internal pull-ups or pull-downs, and it may be necessary to add an external resistor to reinforce the default internal resistor of the Microchip switch. The KSZ9xxx family's datasheet lists all the strapping pins, their functionalities and default values.

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An unmanaged Ethernet switch allows a quick and easy commissioning of the Ethernet network. A wide range of applications, including industrial control applications, can benefit tremendously from adding an unmanaged Ethernet switch, as it reduces the cost and complexity for the Ethernet network.

Unlike a managed switch, an unmanaged Ethernet switch does not require any external microcontroller, microprocessor or SoC to manage its functions. It can easily be configured using strap-in options of the switch. Because of its ease of use it is also known as a “plug and play” device.

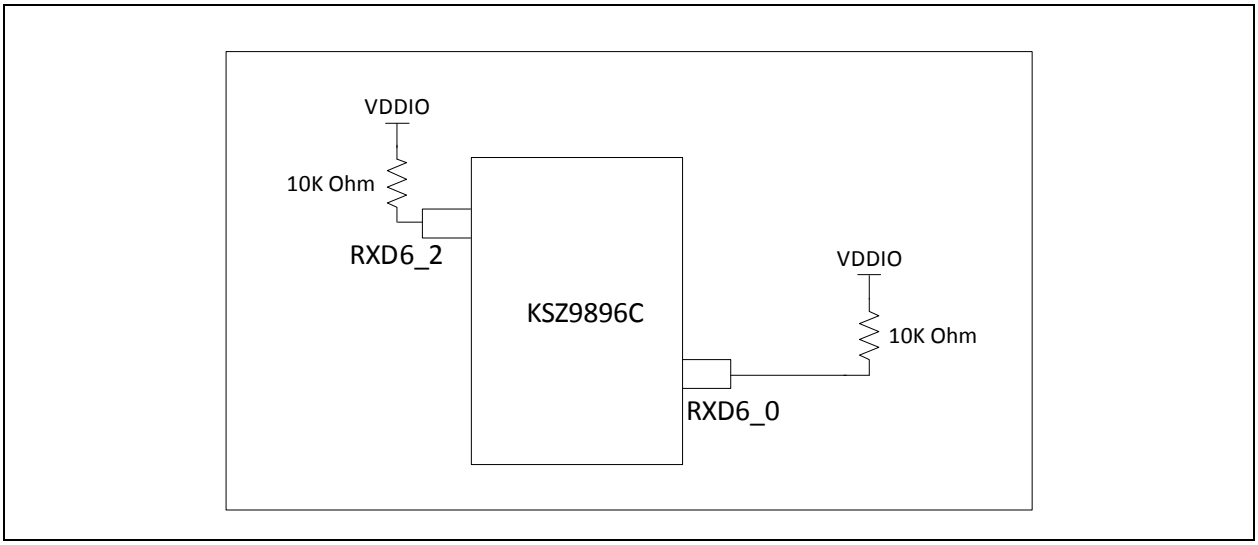
Example Configuration

The Figure 1 example circuit details the KSZ9896C switch in unmanaged mode using configuration straps. The circuit enables auto-negotiation and the SPI interface (to access the internal registers for debugging purposes), sets port 6 to 100Mbps RMII mode. It can be seen from the datasheet table that apart from configuring port 6 in RMII mode and selecting the 100Mbps port 6 speed, the remaining options are set by default. Therefore, a user only needs to use external pull-up resistors as shown in the Table 2.

TABLE 2: CONFIGURATION EXAMPLE

PIN NUMBER	CONFIGURATION STRAP PIN	DESCRIPTION
62, 63	RXD6_3, RXD6_2	Port 6 Mode 01: RMII Note: RXD6_3 includes an internal pull-down resistor.
65	RXD6_0	Port 6 Speed Select 1: 100Mbps Mode Note: If Port 6 is configured for MII or RMII, set the speed to 100Mbps.

FIGURE 1: EXAMPLE CONFIGURATION CIRCUIT



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MICROCONTROLLER CONFIGURATION

In this switch configuration method, the switch's serial bus such as, SPI or I^2C is connected to a small microcontroller to configure its internal functions. The switch acts as a I^2C slave device in the system. Using this serial bus, the microcontroller writes configuration registers during power up of the device, as described in the management interface portion of the data sheet. Configuration strap pins are used to determine the interface mode the switch operates in. For example, in the KSZ9897R, the LED4_1 and LED3_1 pins decide the configuration interface:

LED4_1 LED3_1 = 01 = I^2C Interface Mode

LED4_1 LED3_1 = 1X = SPI Slave Mode

In this method, the serial interface provides access to the switch and PHY access registers. The serial interface provides access to the switch and PHY access registers. Between these two interfaces, SPI is the fastest speed. For example, the KSZ9897 supports up to a 50 MHz bus speed in SPI mode, whereas it only supports a 400Kb bus speed in I^2C mode.

Example Configuration

In this example, the switch's VLAN will be enabled via the SPI or I^2C interface. Figure 2 and Figure 3 detail the example circuits for SPI and I^2C interfaces, respectively. To enable the VLAN, the user must write the following register:

Switch Lookup Engine Control 0 Register: Address 0x0310, bit 7 = 1b

FIGURE 2: SPI INTERFACE CONNECTIONS WITH MCU

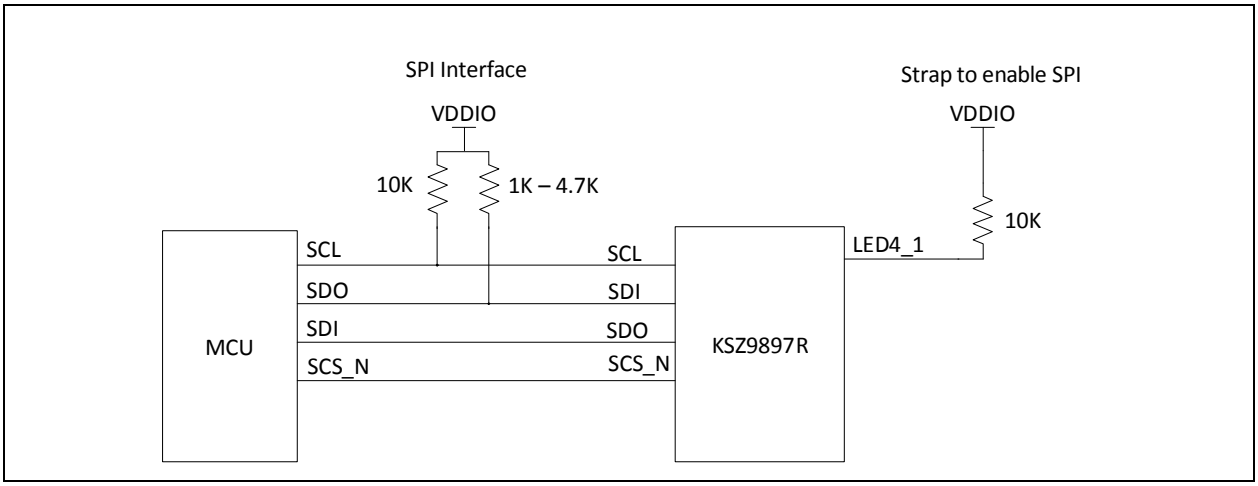
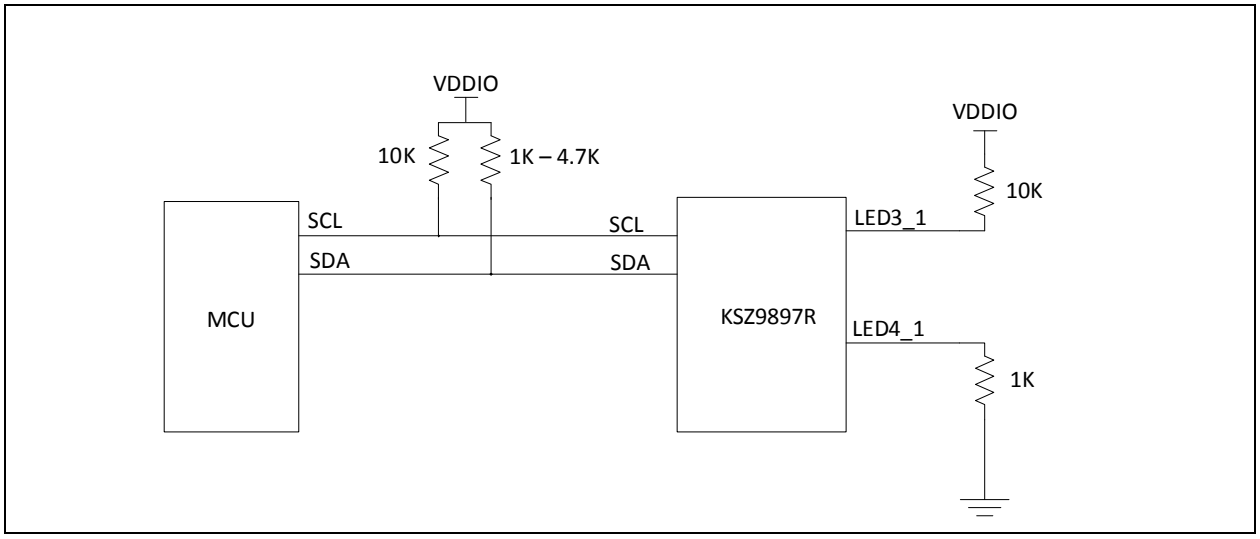


FIGURE 3: I²C INTERFACE CONNECTIONS WITH MCU



The switch's datasheet provides additional information on how to configure the SPI and I²C bus interfaces with a microcontroller. Since this method uses a small microcontroller, the overall solution can be highly cost effective. Since the SPI and I²C interfaces are common interfaces, the connections do not require a high level of technical expertise.

Configuring the switch using a small microcontroller provides two advantages:

1. Since this method uses SPI or I²C bus, the microcontroller can gain access to both the switch and PHY registers sets.
2. If a microcontroller is chosen with a UART peripheral, an RS232 serial port can be added on the PCB for out-of-band switch management.

However, since small MCUs may not have enough memory, using this method may not provide the ability to configure high-end functions of the switch. MCUs are generally used only to pre-configure the switch on power-up and do not handle the packets from the switch port. In order to access and enable high-end functions of the switch, Host Processor Configuration is suggested.

ETHERNET IN-BAND ACCESS (IBA) CONFIGURATION

In this configuration method, the switch is configured through a network data port (Ethernet port). The IBA interface is connected to the switch fabric and can remotely configure major switch functions such as STP, QoS, VLAN assignments, etcetera. A PC-based utility may be used to configure these functions. Prior to using this method, the switch will require IBA to be enabled via the in-band management configuration strap. For example, the KSZ9897R requires that the RX_DV7 pin be pulled-up to VDDIO using a 10KΩ resistor, as shown in Figure 4.

For the Gigabit Ethernet switches mentioned in the Introduction section, the last port is the default IBA port. For exam-

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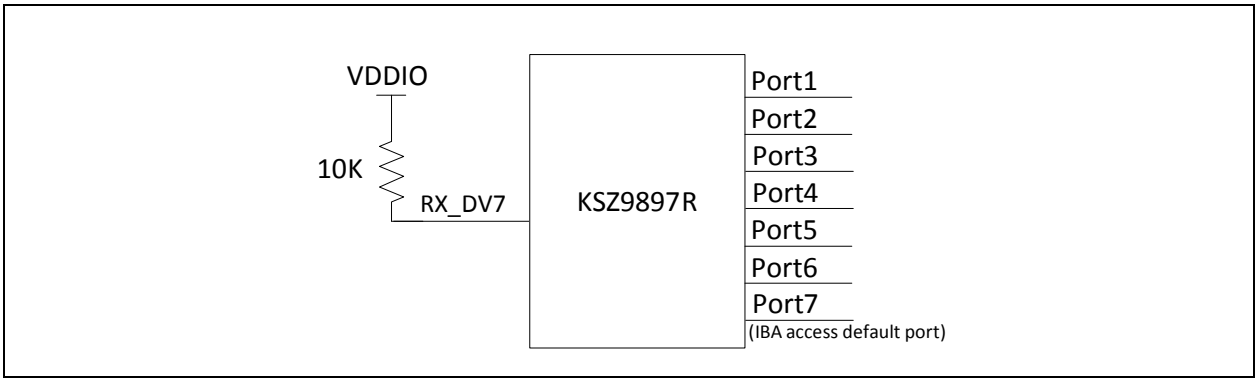
ple, for the KSZ9897 switch, port 7 is the default IBA port and for the KSZ9896 switch, port 6 is the default IBA port and so forth. The IBA port can be changed to a different port of the switch. However, it requires that the switch is connected to a MCU or MPU via SPI or I^2C interface to initially configure the IBA control register to the desired port.

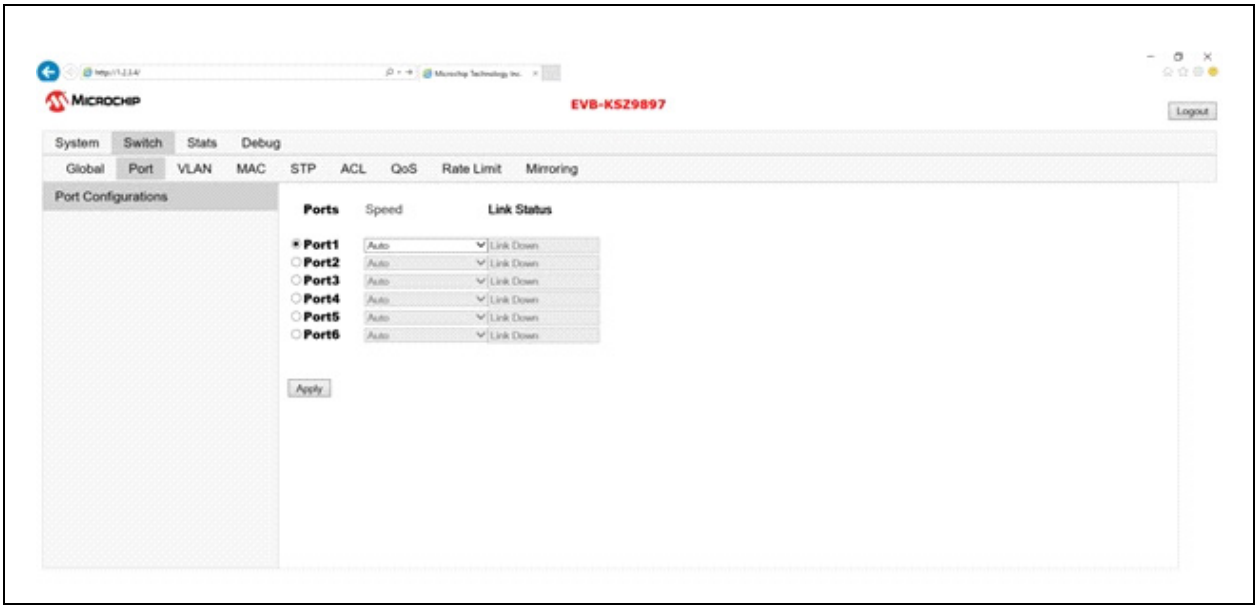
FIGURE 4: IBA CONNECTIONS



The IBA configuration method provides the most efficient way to configure and manage the device, since the same Ethernet data port is used to configure the switch. IBA eliminates the requirements for a separate serial interface and makes building and managing the network more economical. Therefore, this method is extremely useful in complex industrial environments, such as where VoIP services are essential. In this situation, when VoIP traffic requires higher throughput, a user can remotely allocate more bandwidth to the network using the Quality of Service (QoS) function.

The in-band configuration and management method requires a PC application, such as a browser based tool and a host processor. The switches configuration page is accessed using an IP address. Microchip provides an example web-based application, as shown in Figure 5, which is available from a GitHub link on the EVB-KSZ9897 product page.

FIGURE 5: IBA WEB APPLICATION



The application provides an easy way to configure advanced features of the KSZ9897, such as VLAN, STP, ACL, QoS etc.. However, in-band management includes potential for the switch to be isolated and unmanageable if connection to the individual device is lost, for example in a spanning tree loop or if the Ethernet connection is cut accidentally. Additionally, since the switch is easily accessible via a PC and the network, security can be an issue. Because of this, at a minimum, the following precautions should be followed when using this method:

1. The PC accessing the switch should have an adequate security level (i.e., other than the network engineer, no

other person should have access to it.)

2. The PC accessing the switch should be free of any malware or virus.
3. The switch should be accessible only through the organization's internal network and not available to the outside world.

HOST PROCESSOR CONFIGURATION

In this switch configuration method, a high-end host processor is connected to the switch. The processor firmware provides a way to program the configuration registers of the switch. The processor can use either an SPI or I^2C interface to enable the switch functions and PHY functions, whereas the MII Management (MIIM – a.k.a MDC/MDIO) interface can be used to enable the PHY functions of the switch. The switch operates as an SPI or I^2C slave in this method.

Compared to the Microcontroller Configuration method, this technique includes a high-end microprocessor (MPU) with more flash memory and RAM. This allows the MPU to host a complex operating system (OS) such as embedded Linux with a built-in TCP/IP stack which can manage the switch functions and its traffic in addition to configuring the switch. In this setup, the user can use Telnet or a web server application to configure the switch. The stack also includes Simple Network Management Protocol (SNMP) which can be used to manage the switch.

This configuration method is useful in applications where a system needs to be self-contained. Since the host processor can support full features such as a TCP/IP stack, use operating systems such as Linux, and switch management ports such as SPI and I^2C, this method of configuration can be used in a self-contained system solution. The on-board Linux OS can enable and disable switch functions, such as VLAN, which can be difficult in the microcontroller based configuration method. Host processor configuration provides the ability to run advanced protocols such as 1588 and AVB.

Microchip provides an example that shows the configuration of the KSZ9477 device using a SAMA5D3 processor. The hardware and software is available with detailed documentation from the EVB-KSZ9477 evaluation board's web site.

CONFIGURATION METHOD TRADE-OFFS

Table 3 details the trade-offs of using different configuration methods.

TABLE 3: CONFIGURATION METHOD TRADE-OFFS (SHEET 1 OF 2)

	Configuration Straps	Microcontroller	Ethernet IBA	Host Processor
Cost	*Least* Only a few passive components are required to configure the switch	*Moderate* Low end MCU and its supporting circuitry is required	*Moderate* Hardware requires a few passive components and a free PC based utility	*Most* A high-end MPU is required with supporting circuitry and OS
Features	*Low* Enables only basic features	*Moderate* Enables switch and PHY registers	*Moderate* Apart from switch and PHY registers, adds remote switch management	*Advanced* Access to switch and PHY registers, host TCP/IP stack, drivers for advanced features (e.g., AVB, IEEE1588)
Ease of Use	*Easy* Requires basic electronic components and circuit configuration	*Moderate* Requires some knowledge of MCU based application development	*Easy* Example web GUI provided by Microchip	*Moderate* Firmware development, driver installation, and switch/PHY configuration required
Required Expertise	*Basic* Hardware/circuit design knowledge required by the developer	*Basic to Moderate* Requires knowledge of MCU, firmware development, and development tools	*Moderate* User can start with an example web browser or PC based utility	*Moderate* Requires knowledge of Linux OS, MPU development environment

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TABLE 3: CONFIGURATION METHOD TRADE-OFFS (SHEET 2 OF 2)

	Configuration Straps	Microcontroller	Ethernet IBA	Host Processor
System Development Time	*Quickest* All basic features are configured in hardware while developing the PCB	*Moderate* Firmware development is required for MCU	*Moderate* Web based GUI is provided, but remote management may require additional setup	*Most* Requires firmware development and switch drivers

EVALUATION BOARDS

Microchip provides the following development boards to illustrate the different configuration methods explained in this application note:

- KSZ9897 Switch Evaluation Board with LAN7801 & KSZ9031 (Part Number: EVB-KSZ9897)
  - This board is best suited for Configuration Straps or Ethernet In-Band Access (IBA) Configuration evaluation
- KSZ9477 Managed Switch Evaluation board with SAMA5D36 MPU (Part Number: EVB-KSZ9477)
  - This board is best suited for Host Processor Configuration evaluation

A user can access the hardware design files and the software configuration tools from the evaluation board's product page at www.microchip.com.

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APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00002577A (12-01-17)	All	Initial release.

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