AN2661

Getting Started with 3-Port Gigabit Ethernet Switch Configuration Options

Author: *Parthiv Pandya*
Microchip Technology Inc.

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 *(KSZ9893R, KSZ9563R, KSZ8563R)*
- Microcontroller Configuration *(KSZ9893R, KSZ9563R, KSZ8563R)*
- Ethernet In-Band Access (IBA) Configuration *(KSZ9893R, KSZ9563R, KSZ8563R)*
- Host Processor Configuration *(KSZ9893R, KSZ9563R, KSZ8563R)*

TABLE 1: AVAILABLE CONFIGURATION METHODS PER FEATURE

	Basic	Auto-Neg	EEE	VLAN	QoS	IEEE 1588 v2 (Note 2)	802.1x Security	ACL	PME	WoL	AVB (Note 3)
Config. Strap	X	X									
8-bit MCU	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

Note 1: 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.

2: KSZ9893R does not support IEEE 1588 v2.

3: KSZ9893R does not support AVB.

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 KSZ9893R has several strapping pins with internal weak pull-up or pull-down resistors that allow the switch to operate in the unmanaged mode. A user can add 1-kΩ to 10-kΩ external pull-up resistors on non-LED pins, or 750-Ω to 1-kΩ 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 or 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 data sheet lists all the strapping pins, their functionalities, and default values.

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 system on chip (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.

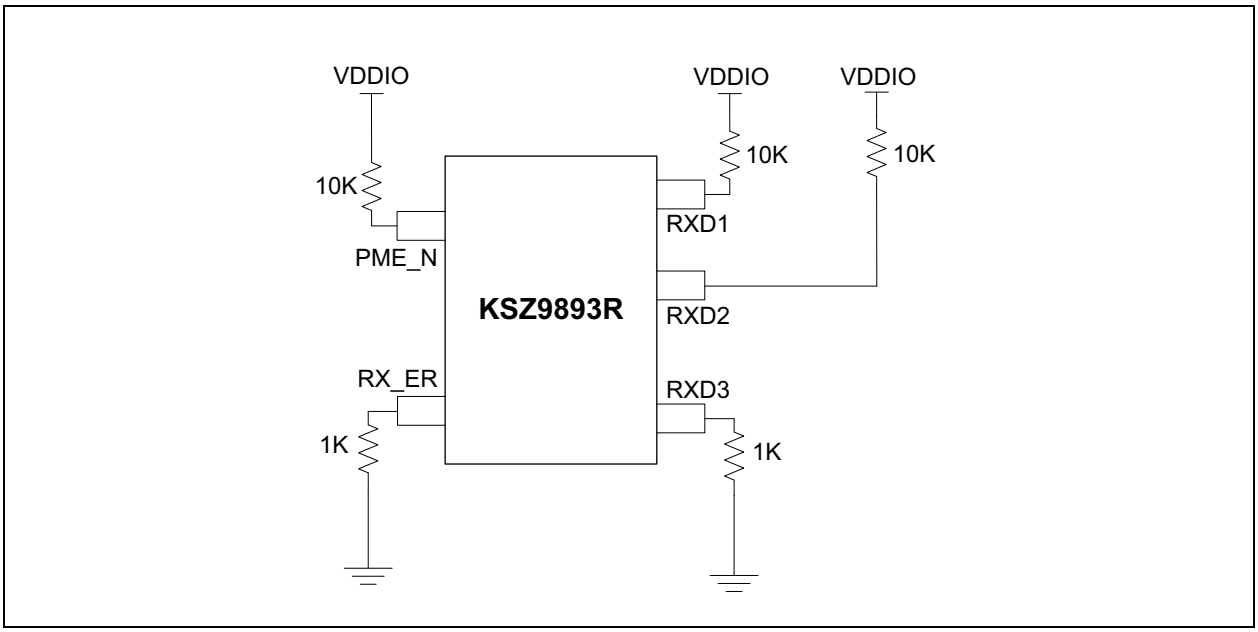
Example Configuration

The example circuit shown in Figure 1 details the KSZ9893R switch in an unmanaged mode using configuration straps. The circuit enables auto-negotiation and the serial peripheral interface (SPI). The SPI can be used to access the internal registers for debugging purposes. The circuit also configures port 3 for RMII mode. Table 2 shows the pin configuration.

TABLE 2: CONFIGURATION EXAMPLE

Pin number	Configuration strap pin	Description
28, 44	RX_ER, PME_N	[RX_ER, PME_N]: Ports 1 and 2 (PHY) Configuration 01: Auto-negotiation enable with EEE (Default)
23, 24	RXD1, RXD0	[RXD1, RXD0]: Serial Interface Mode 1X: SPI
21, 22	RXD3, RXD2	[RXD3, RXD2]: Port 3 (MAC) xMII Mode 01: RMII1:

FIGURE 1: EXAMPLE CONFIGURATION CIRCUIT



Note: For SPI configuration, RXD0 is a "don't care" bit. Therefore, it does not need to be connected to either VDDIO or ground.

MICROCONTROLLER CONFIGURATION

In this switch configuration method, the management bus of the switch, such as SPI or I^{2}C, is connected to a small microcontroller to configure its internal functions. The switch can be configured either as an SPI slave or as an I^{2}C slave device in the system. Using the management bus, the microcontroller has read/write access to the device's configuration registers after device power-up, as described in the management interface section of the data sheet. Configuration strap pins are used to determine the interface mode in which the switch is operating. For example, in the KSZ9893R, the RXD1 and RXD0 pins decide the configuration interface:

RXD1, RXD0 = 01 = I^{2}C Interface mode

RXD1, RXD0 = 1X = SPI Slave mode

The management interfaces provide read/write access to the switch and PHY registers. Between these two interfaces, the SPI provides the fastest speed.

Example Configuration

In this example, the Start Switch bit of the switch will be enabled via the SPI or I^{2}C interface. Figure 2 and Figure 3 detail the example circuits for SPI and I^{2}C interfaces, respectively. To enable the Start Switch bit, the user must write the following register:

Switch Operation Register: Address 0x0300, bit 0 = 1b

FIGURE 2: SPI INTERFACE CONNECTIONS WITH MCU

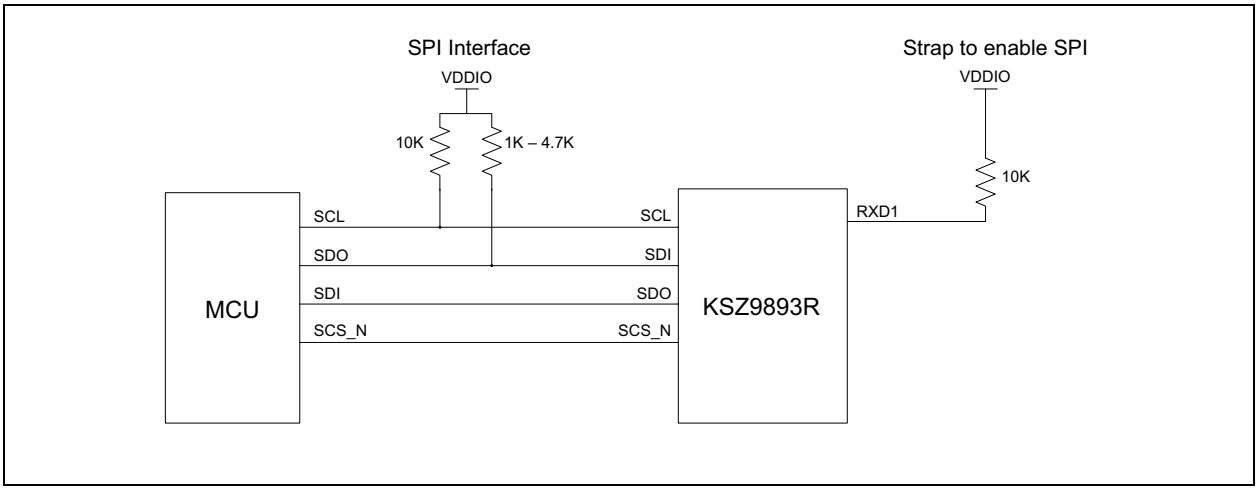
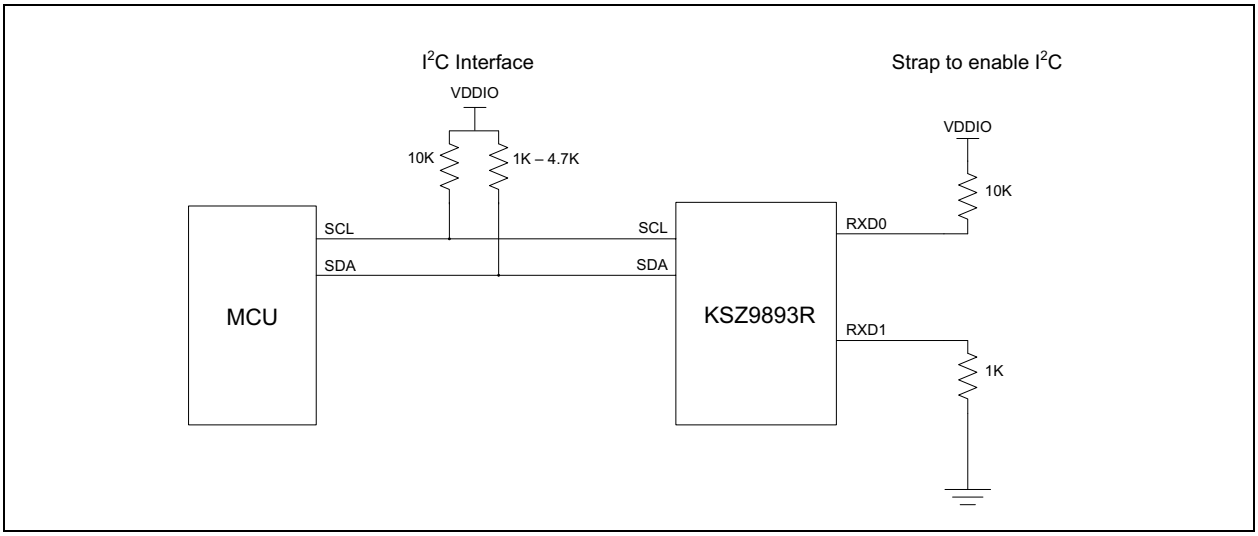


FIGURE 3: I^{2}C INTERFACE CONNECTIONS WITH MCU



The data sheet of the switch 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:

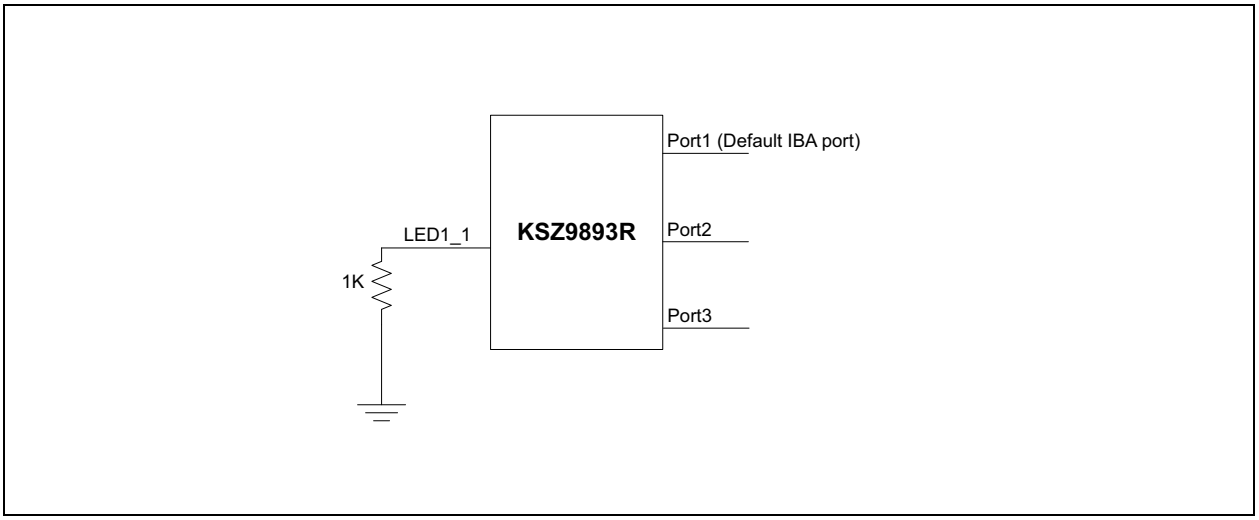
- Since this method uses an SPI or I2C bus, the microcontroller can gain access to both the switch and PHY register sets.
- If a microcontroller is chosen with a UART peripheral, an RS232 serial port can be added on the PCB for out-of-band switch management.

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 preconfigure the switch on power-up and do not handle the packets from the switch port. To access and enable high-end functions of the switch, configuration of a host processor is suggested (see the Host Processor Configuration section).

ETHERNET IN-BAND ACCESS (IBA) CONFIGURATION

In this configuration method, the switch is configured through a network data port (Ethernet port). Register access requests are sent to the switch via Ethernet packets that are identified by a special header tag. In this method, a user can remotely configure switch functions such as spanning tree protocol (STP), quality of service (QoS), VLAN assignments, and so on. A PC-based utility may be used to configure these functions. Prior to using this method, the switch will require the IBA to be enabled via the in-band management configuration strap. For example, the KSZ9893R requires that the LED1_1 pin be pulled down to ground using a 1-kΩ resistor, as shown in Figure 4.

FIGURE 4: IBA PIN STRAPPING



With the IBA pin strapping, PHY port 1 is assigned as the default IBA port. SPI or I2C management is required to enable MAC port 3 (host processor) as the IBA port.

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. This method is extremely useful in complex industrial environments, such as where voice over IP (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 QoS function.

Note: A user can use IBA with I2C or SPI interface.

A switch is easily accessible via a PC, and the network is a security risk. At a minimum, the following precautions should be followed when using this method:

- The PC accessing the switch should have an adequate security level (that is, other than the network engineer, no other person should have access to it).
- The PC accessing the switch should be free of any malware or virus.
- 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 via the RGMII, RMII, or MII interface. The processor firmware provides a way to program the configuration registers of the switch. The processor can use either an SPI, I^2C interface, or IBA to enable the switch functions and PHY functions, whereas the MII Management (MIIM – also known as 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 that 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.

This configuration method is useful in applications where a system must 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 audio-video bridging (AVB).

CONFIGURATION METHOD TRADE-OFFS

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

TABLE 3: CONFIGURATION METHOD TRADE-OFFS

	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 are 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 (for example, 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 or 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
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:

- KSZ9563 Switch Evaluation Board with SAMA5D36A Development Board
- KSZ8563 Switch Evaluation Board with SAMA5D36A Development Board

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

APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00002661A (03-02-18)	Initial release	

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