Product Change Notification - SYST-15YXLG147

Date: 23 Aug 2017

Product Category: Ethernet Switches

Affected CPNs:

Notification subject: ERRATA - KSZ9477S Silicon Errata & Data Sheet Clarification Errata Document Revision

Notification text: SYST-15YXLG147

Microchip has released a new DeviceDoc for the KSZ9477S Silicon Errata & Data Sheet Clarification of devices. If you are using one of these devices please read the document located at KSZ9477S Silicon Errata & Data Sheet Clarification.

Notification Status: Final

Description of Change: Initial document release.

Impacts to Data Sheet: None

Reason for Change: To Improve Productivity

Change Implementation Status: Complete

Date Document Changes Effective: 23 Aug 2017

NOTE: Please be advised that this is a change to the document only the product has not been changed.

Markings to Distinguish Revised from Unrevised Devices: N/A

Attachment(s): KSZ9477S Silicon Errata & Data Sheet Clarification

Please contact your local Microchip sales office with questions or concerns regarding this notification.

Terms and Conditions:

If you wish to change your product/process change notification (PCN) profile please log on to our website at http://www.microchip.com/PCN sign into myMICROCHIP to open the myMICROCHIP home page, then select a profile option from the left navigation bar.

To opt out of future offer or information emails (other than product change notification emails), click here to go to microchipDIRECT and login, then click on the "My account" link, click on "Update profile" and un-check the box that states "Future offers or information about Microchip's products or services."

Affected Catalog Part Numbers (CPN)

KSZ9477STXI-TR
KSZ9477STXI

KSZ9477S

KSZ9477S Silicon Errata and Data Sheet Clarification

This document describes known silicon errata for functional revisions A1 of the KSZ9477S. The silicon errata discussed in this document are for silicon revisions as listed in Table 1. The silicon revision can be determined by the device's top marking. A summary of KSZ9477S silicon errata is provided in Table 2.

Some errata work arounds may require modifying register values. If the system design does not include a processor to manage the switch, a small 8-bit PIC or AVR microcontroller can be used to configure the switch via the I^2C or SPI interface. These low-cost microcontrollers are available in packages as small 8-pins, with integrated oscillator and non-volatile program memory. The microcontroller does not need a MII or RMII connection to the switch. Alternatively, the switch can be configured by a remote computer via the in-band management feature of the switch. The default port for in-band management is port 7.

TABLE 1: AFFECTED SILICON REVISIONS

Part Numbers	Silicon Revision	Package Top Mark
KSZ9477STX	A1	B000

TABLE 2: SILICON ISSUE SUMMARY

Item Number	Silicon Issue Summary	Affected Silicon Revisions
1.	Register settings are needed to improve PHY receive performance	A1
2.	Transmit waveform amplitude can be improved (1000BASE-T, 100BASE-TX, 10BASE-Te)	A1
3.	Default RGMII ingress timing does not comply with the RGMII specification	A1
4.	Energy Efficient Ethernet (EEE) feature select must be manually disabled	A1
5.	Toggling PHY Powerdown can cause errors or link failures in adjacent PHYs	A1
6.	Certain PHY registers must be written as pairs instead of singly	A1
7.	SGMII auto-negotiation does not set bit 0 in the auto-negotiation code word	A1
8.	SGMII port link details from the connected SGMII PHY are not passed properly to the port 7 GMAC	A1
9.	Register settings are required to meet data sheet supply current specifications	A1
10.	Automatic SPI Data Out Edge Select may cause issues	A1
11.	1000BASE-T Transmitter Distortion fails to meet IEEE compliance specification	A1
12.	No Pause frames are generated for ingress rate limiting with an EEE link	A1
13.	Link drop can occur when back pressure is enabled in 100BASE-TX half-duplex mode	A1
14.	Port may hang in half-duplex mode when No Excessive Collision Drop feature is enabled	A1
15.	Frame Length Field Check mode is disabled	A1
16.	SGMII registers are not initialized by hardware reset	A1

Silicon Errata Issues

Module 1: Register settings are needed to improve PHY receive performance

DESCRIPTION

The default receiver settings are not optimized. Receive errors may occur, especially at longer cable lengths.

END USER IMPLICATIONS

For best receiver performance, users should write the following PHY MMD registers. This is done individually for each port (1-5) using any of the management interfaces: MDC/MDIO, I^2C, SPI, or in-band.

Work around

Write to the following MMD registers for each PHY port [1-5]:

[MMD]	[register]	[data]
0x01	0x6F	0xDD0B
0x01	0x8F	0x6032
0x01	0x9D	0x248C
0x01	0x75	0x0060
0x01	0xD3	0x7777
0x1C	0x06	0x3008
0x1C	0x08	0x2001

PLAN

This erratum will not be corrected in a future revision.

Module 2: Transmit waveform amplitude can be improved (1000BASE-T, 100BASE-TX, 10BASE-Te)

DESCRIPTION

The transmit waveform amplitude can be improved for 10BASE-Te, 100BASE-TX and 1000BASE-T.

END USER IMPLICATIONS

With the default settings, the waveform amplitude may be outside the specifications in some corner case conditions, and the transmitter may not be fully compliant with the IEEE standard. This may degrade performance under some conditions.

Work around

Write to the following MMD registers for each PHY port [1-5]:

[MMD]	[register]	[data]
0x1C	0x4	0x00D0

PLAN

This erratum will not be corrected in a future revision.

Module 3: Default RGMII ingress timing does not comply with the RGMII specification

DESCRIPTION

The RGMII defining document specifies a typical data-to-clock setup time into the receiver (switch signals TXD6_[3:0], TX_ER6 and TX_EN6 to TX_CLK6) of 1.8ns. However, port 6 requires additional setup time in order to avoid ingress data errors on this interface. Refer to the data sheet for details.

This issue does not occur on port 7, and there are no timing issues with the MII and RMII modes.

END USER IMPLICATIONS

Careful analysis of the RGMII timing must be performed, considering the timing of both connected devices, and relative signal delay times on the PCB.

Work around

Additional PCB trace delay may be needed on the TX_CLK6 clock signal into port 6 of the switch. Another option is to set the ingress delay bit [4] in register 0x6301. Refer to the data sheet for timing details.

PLAN

This erratum will not be corrected in a future revision.

Module 4: Energy Efficient Ethernet (EEE) feature select must be manually disabled

DESCRIPTION

The EEE feature is enabled by default, but it is not fully operational. It must be manually disabled through register controls. If not disabled, the PHY ports can auto-negotiate to enable EEE, and this feature can cause link drops when linked to another device supporting EEE.

END USER IMPLICATIONS

If the link partner does not support EEE, then EEE will not be activated and there will be no problem with link drops. This is also true if auto-negotiation is disabled, since EEE is activated only if auto-negotiated between the two link partners.

If the link partner is not known, or if the link partner is EEE capable, then the EEE feature should be manually disabled to avoid link drop problems.

Work around

Disable EEE by writing to the following registers. This is done individually for each PHY port (1-5) using any of the management interfaces: MDC/MDIO, I^2C, SPI, or in-band.

EEE is disabled by clearing bits [2:1] of the PHY indirect register: MMD 7, address 3Ch.

MMD register:

[MMD]	[register]	[data]
7	0x3C	0x0000

PLAN

This erratum will not be corrected in a future revision.

Module 5: Toggling PHY Powerdown can cause errors or link failures in adjacent PHYs

DESCRIPTION

The PHY power down is controlled by bit 11 in registers 0xN100-0xN101. It provides separate power down control for each PHY. When a PHY is brought out of power down by clearing this bit, the resulting power surge can disrupt an adjacent PHY, causing data errors or temporary link down on that port.

END USER IMPLICATIONS

Data errors or link down can occur in an active PHY when its neighbor is brought out of power down mode.

Work around

Avoid dynamically changing the power down state of any PHYs if other PHYs may be linked and active. Only change the power up or power down state of a PHY when no other PHYs on the chip are linked and possibly passing traffic.

PLAN

This erratum will not be corrected in a future revision.

Module 6: Certain PHY registers must be written as pairs instead of singly

DESCRIPTION

When using SPI, I^2C, or in-band register access, writes to certain PHY registers are performed as 32-bit writes instead of 16-bit writes.

The PHY control and status registers are 16-bit registers. They occupy the byte address range 0xN100 to 0xN13F, where N is the port number. Registers from 0xN100 to 0xN11F function normally and can be written either 16- or 8-bits at a time.

An error in the register access logic causes all writes from 0xN120 to 0xN13F to be 32-bit writes. For example, a 16-bit write to register 0xN122-0xN123 also results in all zeros being written to register 0xN120-0x121. Also, a 16-bit write to register 0xN120-0xN121 causes all zeros to be written to 0xN122-0xN123.

END USER IMPLICATIONS

This issue is relevant only to write operations, not to reads. When writing only 16-bits to a register in this address range, all zeros will be written to the adjacent register. This may change the PHY settings and cause the PHY to malfunction.

Work around

To avoid writing zero to an adjacent register, always write the registers in this address range in pairs as 32-bits:

0xN120 - 0xN123

0xN124 - 0xN127

0xN128 - 0xN12B

0xN12C - 0xN12F

Note that some of these registers are not defined in the data sheet. In order to avoid writing inappropriate data to any undefined register, the register should be read before writing (i.e. read-modify-write). Do not assume that undocumented registers should be all zeros.

PLAN

This erratum will not be corrected in a future revision.

Module 7: SGMII auto-negotiation does not set bit 0 in the auto-negotiation code word

DESCRIPTION

Port 7 SGMII auto-negotiation sends the incorrect code word “0x0000”, instead of “0x0001” as defined in the SGMII specification. If the connected SGMII device requires that bit 0 be set, then this can prevent successful auto-negotiation. Some SGMII devices require that bit 0 is set, while other devices don't care.

END USER IMPLICATIONS

Many SGMII devices ignore the value of the code word received during auto-negotiation, but some will not auto-negotiate properly when an incorrect value is received.

Work around

If the connected SGMII device does not care about the value of the code word, then this workaround is not needed.

The workaround is to write to port 7 SGMII register 0x1F0004. This only needs to be done once after the chip is powered up or reset.

Using either the SPI, I^2C, or in-band management interface, perform the following writes:

[addr]	[data]	
0x7200	0x001F0004	(32-bits)
0x7206	0x01A0	(16-bits)

PLAN

This erratum will not be corrected in a future revision.

Module 8: SGMII port link details from the connected SGMII PHY are not passed properly to the port 7 GMAC

DESCRIPTION

Link information from the connected SGMII PHY is not automatically forwarded from the SGMII interface to the internal PCS block. The GMAC therefore does not automatically know the speed (10/100/1000) and duplex of the link established by the PHY connected to the SGMII interface. If the PCS configuration and the PHY link conditions do not match, the port will not function properly.

END USER IMPLICATIONS

This applies to port 7 operated in the (default) SGMII MAC mode. It is not applicable for (non-default) SGMII PHY mode.

The SGMII interface can operate at any of three speeds: 10, 100 or 1000 Mbps. The speed is determined by the link speed of the SGMII PHY attached to port 7 and is communicated by auto-negotiation to port 7. Though this information is received at port 7, it is not forwarded to the port 7 PCS.

The GMAC defaults to 1000 Mbps, so if the SGMII link is always 1000 Mbps, then there is no problem and a workaround is not needed.

If the SGMII speed is variable or less than 1000 Mbps, software must actively read the link details from one register and write it to another register whenever a link up condition occurs or when there is a change to the link speed.

Work around

Software must actively read the link status (up or down), speed and duplex from one SGMII register and write it to another SGMII register whenever the link conditions change. Two methods are available for detecting a change in link speed:

1. Polling. Software reads SGMII indirect register 0x1f8002.
2. SGMII AN Complete interrupt.

The link speed is read from the SGMII indirect register 0x1F8002, bits [3:2]:

10 = 1000 Mbps

01 = 100 Mbps

00 = 10 Mbps

The speed must be written to SGMII indirect register 0x1F0000, bits [6, 13]:

10 = 1000 Mbps

01 = 100 Mbps

00 = 10 Mbps

Use either the SPI, I^2C or in-band management interface to access the indirect SGMII registers. Because they are indirect, two writes are needed to write to an SGMII register. An SGMII read is accomplished by a write followed by a read:

[addr]	[data]	
`Write 0x7200`	`0x001F8002`	set up to read reg 1F8002
`Read 0x7206`	`0xXXXX`	read reg 1F8002 (16-bits)
`Write 0x7200`	`0x001F0000`	set up to write reg 1F0000
`Write 0x7206`	`0x1140`	write reg 1F0000

When writing indirect register 0x1F0000, use the following values for these link speeds:

0x1140 for 1000 Mbps full duplex

0x3100 for 100 Mbps full duplex

0x1100 for 10 Mbps full duplex

PLAN

This erratum will not be corrected in a future revision.

Module 9: Register settings are required to meet data sheet supply current specifications

DESCRIPTION

The power supply current specifications in the data sheet are based on the following register settings. Without these register changes, the AVDDH current is approximately 40% greater, the AVDDL current is approximately 56% greater, and total chip power is approximately 26% greater when all PHY ports are linked at 1000Mb/s.

END USER IMPLICATIONS

If the following register settings are not made, the chip can dissipate more power than indicated in the data sheet for the AVDDH and AVDLL power rails. This means that under the worst case conditions (all PHY ports linked at 1000 Mb/s), the junction temperature may approach or exceed 125°C when operating at the maximum ambient temperature. Device and system thermal analysis should use the increased AVDDH and AVDLL current values if the following register settings are not made. The voltage regulators supplying AVDDH and AVDLL must also have adequate current capacity.

Work around

Write to the following MMD registers for each PHY port [1-5]:

[MMD]	[register]	[data]
0x1C	0x13	0x6EFF
0x1C	0x14	0xE6FF
0x1C	0x15	0x6EFF
0x1C	0x16	0xE6FF
0x1C	0x17	0x00FF
0x1C	0x18	0x43FF
0x1C	0x19	0xC3FF
0x1C	0x1A	0x6FFF
0x1C	0x1B	0x07FF
0x1C	0x1C	0x0FFF
0x1C	0x1D	0xE7FF
0x1C	0x1E	0xEFFF
0x1C	0x20	0xEEEE

PLAN

This erratum will not be corrected in a future revision.

Module 10: Automatic SPI Data Out Edge Select may cause issues

DESCRIPTION

Automatic SPI Data Out Edge Select is a feature that is normally enabled in register 0x0100. It detects the SPI clock frequency and selects either the rising clock edge or falling clock edge to clock out the SPI data based on that frequency. The behavior is not fully predictable when the SPI clock frequency is near 25MHz, which may cause the SPI interface to stop functioning. Also, it does not adapt to changes in the SPI clock frequency.

END USER IMPLICATIONS

The SPI interface may stop functioning if the inappropriate clock edge is selected, or if the clock rate changes. Generally there is no problem when operating at lower clock rates, such as below 15 MHz.

Work around

When operating the SPI above 15 MHz, it is suggested to disable the automatic feature by clearing register 0x0100 bit 1, and at the same time setting bit 0 to the desired value to manually select the mode of operation.

PLAN

This erratum will not be corrected in a future revision.

Module 11: 1000BASE-T Transmitter Distortion fails to meet IEEE compliance specification

DESCRIPTION

The device's 1000BASE-T Transmitter Distortion is approximately 40mV, versus the <10mV indicated in the IEEE specification.

END USER IMPLICATIONS

It is unlikely this specification failure will impact system performance. The following link to the Gigabit Transmit Distortion Testing document on the IEEE802.org website also questions the validity of this measurement:

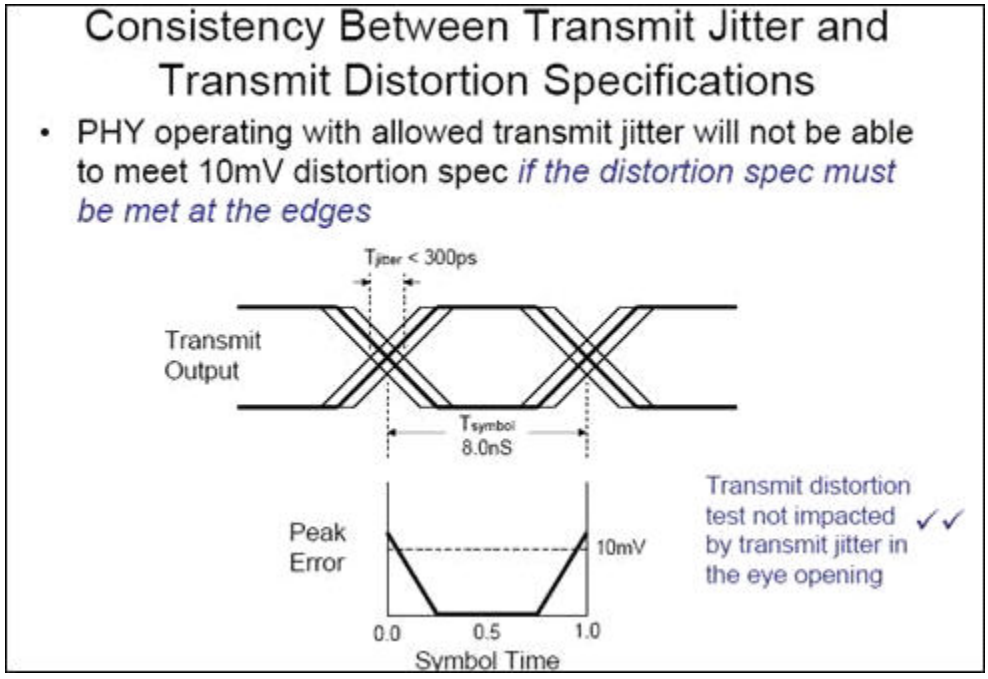
http://www.ieee802.org/3/axay/public/may_07/sefidvash_1_0507.pdf

IEEE testing calls for <10mV peak transmitter distortion for at least 60% of the UI within the eye opening. However, this measurement might not be valid, as the transmit distortion test is sensitive to transmit jitter. Refer to the explanation below, taken from the aforementioned IEEE document.

The Gigabit Transmit Distortion Testing document indicates:

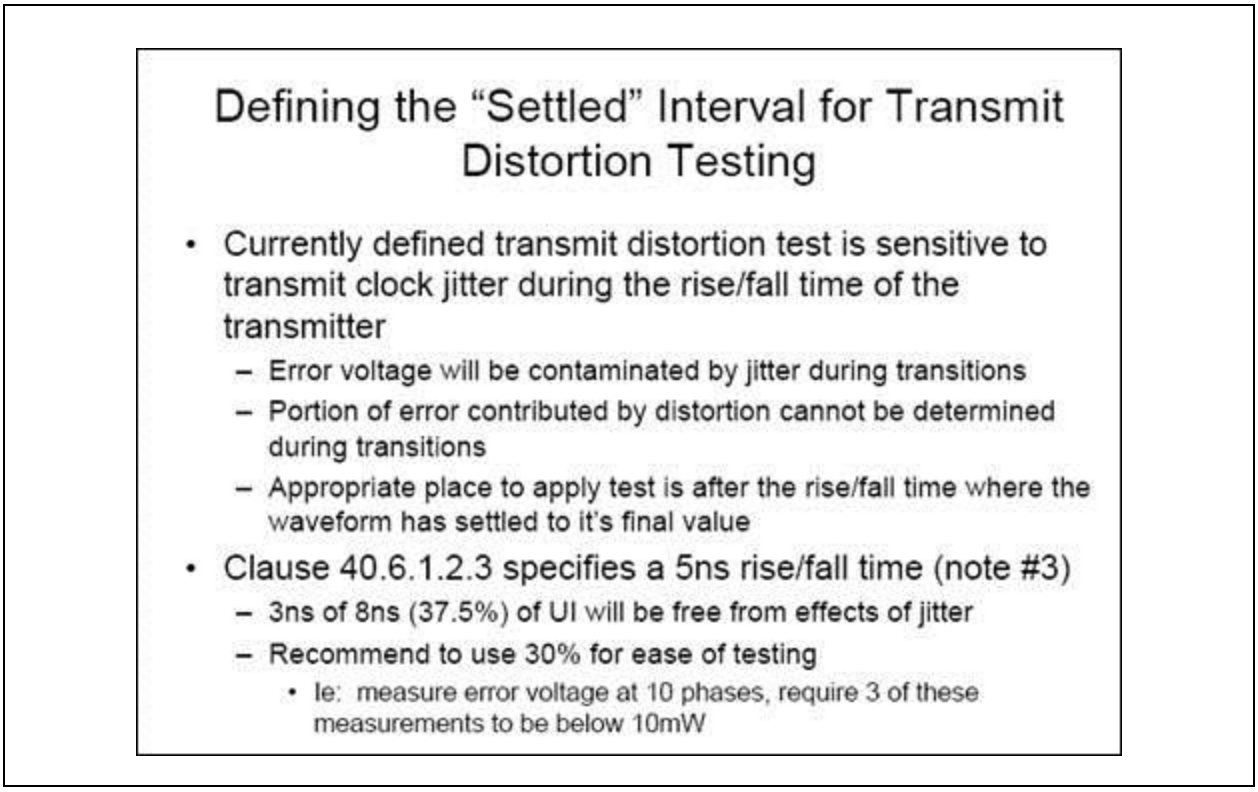
- On page 6, a contradiction between Transmit Jitter and Transmit Distortion requirements:

FIGURE 1: IEEE DOCUMENT PAGE 6



- On page 7:
  - The transmit distortion test is sensitive to transmit clock jitter during the rise/fall time.
  - It is recommended to change the requirement to use at least 30%, instead of at least 60%, of the UI within the eye opening for the <10mV peak transmitter distortion.

FIGURE 2: IEEE DOCUMENT PAGE 7



Extensive testing has been performed to ensure the device can inter-operate with different Gigabit PHY link partners.

Work around

None.

PLAN

This erratum will not be corrected in a future revision.

Module 12: No Pause frames are generated for ingress rate limiting with an EEE link

DESCRIPTION

When an Energy Efficient Ethernet (EEE) link is established with another device, and ingress rate limiting is set up, the port may not generate Pause frames in response to ingress traffic exceeding the rate limit. It also assumes that the Ingress Rate Limit Flow Control Enable bit in register 0xN403 has been set.

END USER IMPLICATIONS

If Pause frames are not generated by the switch, then the link partner will not be able to regulate the rate at which it sends traffic, making ingress rate limiting ineffective. Note that when the flow control function is enabled for ingress rate limiting, the ingress port will not drop packets when the rate limit is exceeded - it relies only on flow control for limiting the ingress rate.

Work around

The problem can be resolved by writing to the following three global registers. Note that these registers may not be documented in the data sheet.

Global registers:

[addr]	[data]
0x03C0	0x4090
0x03C2	0x0080
0x03C4	0x2000

PLAN

This erratum will not be corrected in a future revision.

Module 13: Link drop can occur when back pressure is enabled in 100BASE-TX half-duplex mode

DESCRIPTION

When back pressure is enabled for 100BASE-TX half duplex mode, CRS-based back pressure is the default mode. In this mode, if the switch forwards long packets and the link partner is set up to detect and respond to jabber, then the link partner may drop link. The link down condition is temporary.

END USER IMPLICATIONS

If all of the above conditions are met, then this problem is likely to occur, which will be disruptive, even though it is self-healing. If any of the above conditions are not present, then the problem will not occur. In general, half-duplex is not common. It is also very uncommon for NICs or switches to implement jabber-based link drop since they are normally full-duplex. This function is seen mostly in hubs, which are half duplex.

Work around

The workaround is to change the back pressure mode from CRS-based to collision-based by clearing bit 5 in register 0x0331. This completely eliminates the link drop problem. This register can be written using the SPI, I^2C, or in-band management interface, but not via the MIIM interface.

Global register:

[addr]	[data]
0x0331	0xD0

PLAN

This erratum will not be corrected in a future revision.

Module 14: Port may hang in half-duplex mode when No Excessive Collision Drop feature is enabled

DESCRIPTION

This issue is seen when two of these switch devices are connected together and are configured in the same way. The two devices use the same back-off algorithm and their back-off can become synchronized, causing lock-up.

END USER IMPLICATIONS

“No excessive collision drop” is a feature that may be used for half duplex to potentially improve collision performance. It is controlled in register 0x0300, and is disabled by default. If it is enabled and the link partner is a similar device, then lock up can occur on the link. It will persist until the link is broken (either physically or by register) and re-established.

Work around

The problem is avoided by enabling the Alternate back-off algorithm when using the No excessive collision drop feature. This is done by setting bit 7 in register 0x0330. This register can be written using the SPI, I^2C, or in-band management interface, but not via the MIIM interface.

PLAN

This erratum will not be corrected in a future revision.

Module 15: Frame Length Field Check mode is disabled

DESCRIPTION

Received frames should be dropped if the frame length does not match the value in the frame length field of the frame header. This Frame Length Field Check function is available in this switch, but by default it is disabled. It is enabled or disabled by bit 3 in register 0x0330.

END USER IMPLICATIONS

The effect of this function is minor and is unlikely to be noticed in the network.

Work around

Enable the Frame Length Field Check by setting bit 3 in register 0x0330. This register can be written using the SPI, I^2C, or in-band management interface, but not via the MIIM interface.

PLAN

This erratum will not be corrected in a future revision.

Module 16: SGMII registers are not initialized by hardware reset

DESCRIPTION

The reset pin RST_N and the Soft Hardware Reset control bit do not reset the SGMII registers.

END USER IMPLICATIONS

When asserted, reset pin RST_N and Soft Hardware Reset bit (register 0x300, bit 1) will reset all device registers to their default state, with the exception of the SGMII registers. An additional step is required to reset the SGMII registers, but only when the user feels that a complete device reset is required. Typically it is never necessary to take this action. The SGMII registers are automatically initialized at power up.

Work around

If a reset of the SGMII interface is required, set the SGMII reset bit located in SGMII register 0x1F0000, bit 15. Write the following global registers:

[addr]	[data]	
0x7200	0x001F0000	(32-bits)
0x7206	0x9140	(16-bits)

PLAN

This erratum will not be corrected in a future revision.

APPENDIX A: DOCUMENT REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS80000754A (08-10-17)	All	Initial release.

THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com. Under "Support", click on "Customer Change Notification" and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://microchip.com/support

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

ISBN: 9781522420125

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
═ ISO/TS 16949 ═

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon

Hong Kong
Tel: 852-2943-5100
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-3326-8000
Fax: 86-21-3326-8021

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

ASIA/PACIFIC

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880- 3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

France - Saint Cloud
Tel: 33-1-30-60-70-00

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-67-3636

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7289-7561

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820