General Description

The KS8993 contains three 10/100 physical layer transceivers, three MAC (Media Access Control) units with an integrated layer 2 switch. The device runs in two modes. The first mode is a three port integrated switch and the second is as a three port switch with the third port decoupled from the physical port. In this mode access to the third MAC is provided using a reverse or forward MII (Media Independent Interface) such that an external MAC can be directly connected to the KS8993. This interface also supports the 7-wire (serial network interface) as used by some routing devices.

Useful configurations include a stand alone three port switch as well as a two port switch with a routing element connected to the extra MII port. The additional port is also useful for public network interfacing.

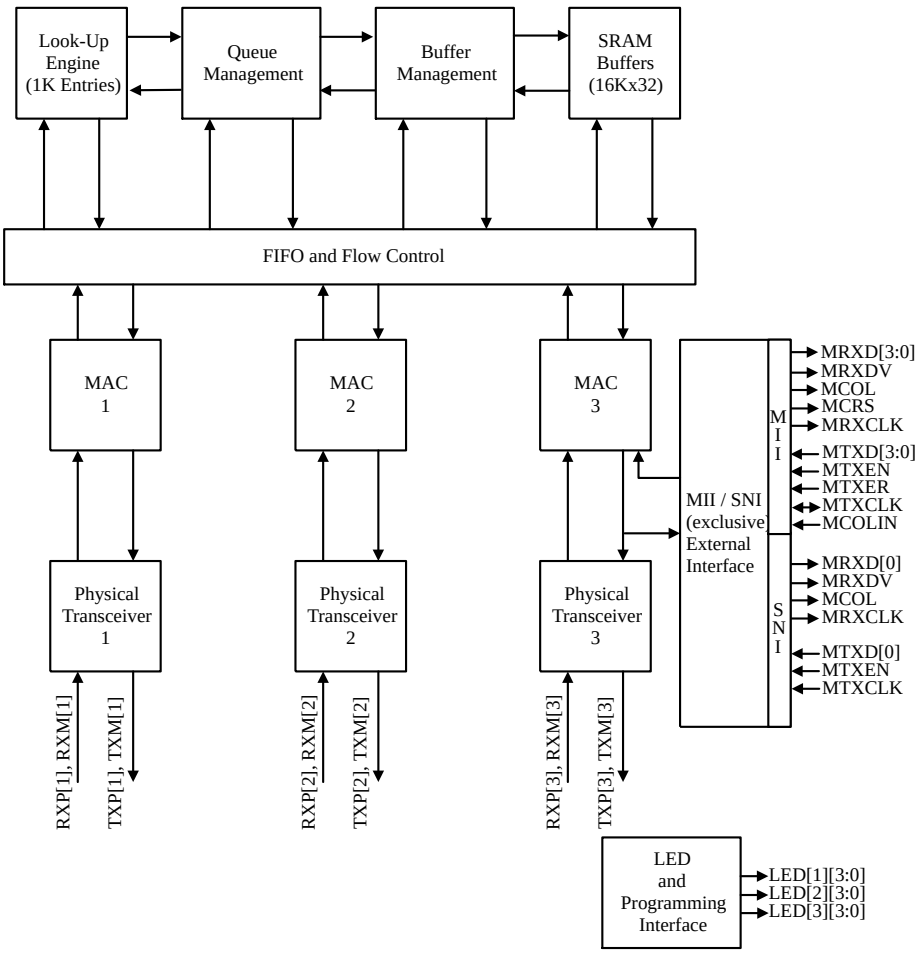
The KS8993 has rich features such as VLAN and priority queuing and is designed to reside in an unmanaged design not requiring processor intervention. This is achieved through I/O strapping at system reset time.

On the media side, the KS8993 supports 10BaseT, 100BaseTX and 100BaseFX as specified by the IEEE 802.3 committee.

Physical signal transmission and reception are enhanced through use of analog circuitry that makes the design more efficient and allows for lower power consumption and smaller chip die size.

Data sheets and support documentation can be found on Micrel's web site at www.micrel.com.

Functional Diagram



Features

- 3-port 10/100 integrated switch with physical layer transceivers
- 64k Byte of SRAM on chip for frame buffering
- 1.0Gbps high performance memory bandwidth
- 10BaseT, 100BaseTX and 100BaseFX modes of operation
- Support for UTP or fiber installations
- Superior analog technology for reduced power and die size
- Supports port based VLAN
- QoS feature!! Supports 802.1p based priority or port-based priority
- Indicators for link, activity, full/half-duplex and speed
- Unmanaged operation via strapping at system reset time
- Hardware based 10/100, full/half, flow control and auto-negotiation
- Individual port forced modes (full-duplex, 100BaseTX) when auto-negotiation is disabled
- Wire speed reception and transmission
- On chip integrated address look-up engine, supports 1K absolute MAC addresses
- Automatic address learning, address aging and address migration
- Full-duplex IEEE 802.3x flow control (Pause) with force mode option
- Half-duplex back pressure flow control
- Comprehensive LED support
- External MAC interface (MII or SNI 7-wire) for router applications
- 300mA (0.75W) including physical transmit drivers
- Commercial temperature range: 0°C to +70°C
- Available in 128-pin PQFP with single 2.5V power supply

Ordering Information

Part Number		Temperature Range	Package
Standard	**Pb-Free**		
KS8993	KSZ8993	0°C to +70°C	128-Pin PQFP

Revision History

Revision	Date	Summary of Changes
1.00	04/13/00	Document origination
1.01	05/31/00	Miscellaneous changes
1.02	06/08/00	Index repair
1.03	09/20/00	MII forward correction. MRXD[3:1] correction.
1.04	10/30/00	Update voltage ratings.
1.05	10/31/00	Correct I/O descriptions.
1.06	11/08/00	Correct mode operation for LED[1:3][0] Add timing information
1.07	12/21/00	Correct pin information
1.08	03/23/01	Correct VLAN description.
1.09	03/26/01	Update MODESEL descriptions for packet size extensions
1.10	04/19/01	Update electrical characteristics; Correct I/O information.
1.11	04/20/01	Correct timing information
1.12	05/10/01	Update I/O descriptions
1.13	06/08/01	Define control for LED[3][3]
1.14	06/26/01	Revise definition for LED[3][3]
1.15	08/1/01	Update timing information and power dissipation Add power up timing description; Correct DISAN3 default mode.
1.16	08/9/01	Correct LED [1] [1] to float configuration Add Reverse and Forward MII timing
2.00	4/8/02	Correct reserve buffer from 128 to 96 for PRSV pin. Add max. current. Add force flow control Option as follows: Change pin 50 from reserved to FFLOW1# for force flow control on port 1.) Change pin 46 from reserved to FFLOW2# for force flow control on port 2. Modify LED[1][2] for force flow control on port 3.
2.01	5/6/02	Add TX Disable for Port 1 and port 2, Power down for port 3 and Far end Fault Disable features using MUX[1:2] and TEST[1:2] pins.
2.02	7/2/02	Recommend pull-down on LED[3][3]
2.03	8/29/03	Convert to new format.
2.04	1/24/05	Added reset circuit recommendation.
2.05	5/12/05	Added lead-free part number

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System Level Applications

The KS8993 can be configured to fit either in a three port 10/100 application or as a two port 10/100 network interface with an extra MII or SNI port. This MII/SNI port can be connected to an external processor and used for routing purposes or public network access. The major benefits of using the KS8993 are the lower power consumption, unmanaged operation, flexible configuration and built in frame buffering. Two such applications are depicted below.

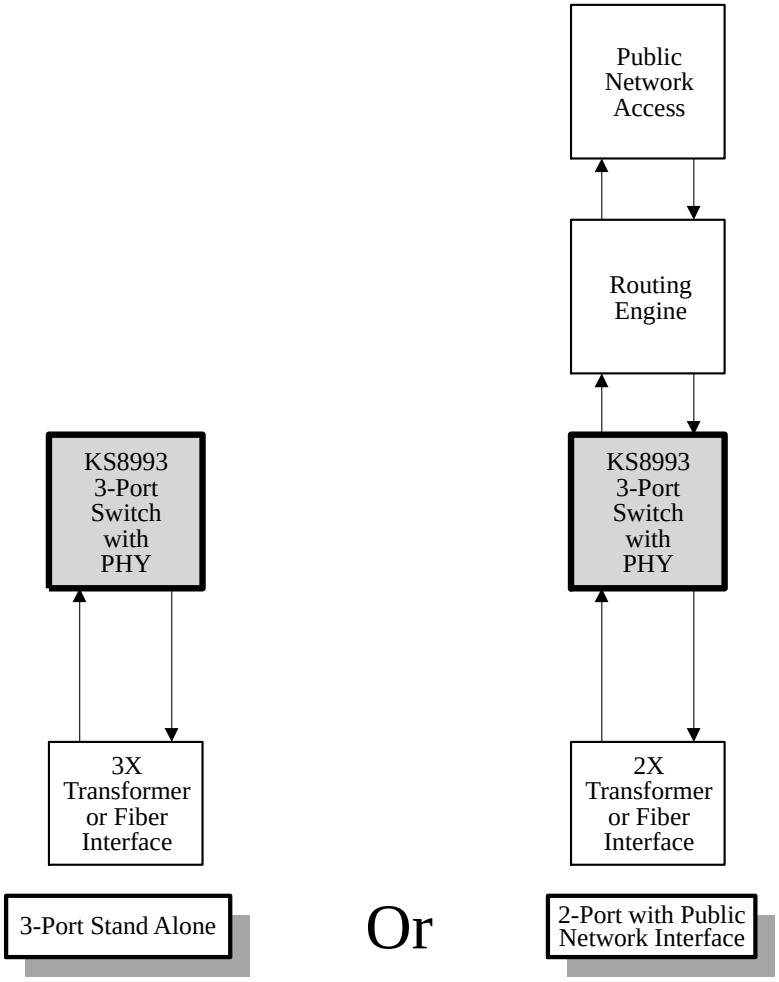


Figure 1. KS8993 Applications

Pin Description

Pin Number	Pin Name	Type(Note 1)	Port	Pin Function
1	GND_ANA	GND		Analog ground
2	MUX[2]	I		Factory test pin
3	MUX[1]	I		Factory test pin
4	GND_RX[1]	GND	1	Ground for receiver
5	RXP[1]	I	1	Physical receive signal + (differential)
6	RXM[1]	I	1	Physical receive signal - (differential)
7	VDD_RX[1]	Pwr	1	2.5V for receiver
8	VREF[1]	O	1	Reference voltage for transmit transformer center tap
9	TXP[1]	O	1	Physical transmit signal + (differential)
10	TXM[1]	O	1	Physical transmit signal - (differential)
11	GND_TX[1]	GND	1	Ground for transmit circuitry
12	VDD_TX[1]	Pwr	1	2.5V for transmit circuitry
13	VDD_BG	Pwr		2.5V for analog circuitry
14	ISET	O		Set physical transmit output current
15	GND_BG	GND		Ground for analog circuitry
16	GND_PLL	GND		Ground for phase locked loop circuitry
17	VDD_PLL	Pwr		2.5V for phase locked loop circuitry
18	GND_RX[2]	GND	2	Ground for receiver
19	RXP[2]	I	2	Physical receive signal + (differential)
20	RXM[2]	I	2	Physical receive signal - (differential)
21	VDD_RX[2]	Pwr	2	2.5V for receiver
22	VREF[2]	O	2	Reference voltage for transmit transformer center tap
23	TXP[2]	O	2	Physical transmit signal + (differential)
24	TXM[2]	O	2	Physical transmit signal - (differential)
25	GND_TX[2]	GND	2	Ground for transmit circuitry
26	VDD_TX[2]	Pwr	2	2.5V for transmit circuitry
27	VDD_TX[3]	Pwr	3	2.5V for transmit circuitry
28	GND_TX[3]	GND	3	Ground for transmit circuitry
29	TXP[3]	O	3	Physical transmit signal + (differential)
30	TXM[3]	O	3	Physical transmit signal - (differential)
31	VREF[3]	O	3	Reference voltage for transmit transformer center tap
32	VDD_RX[3]	Pwr	3	2.5V for receiver
33	RXP[3]	I	3	Physical receive signal + (differential)
34	RXM[3]	I	3	Physical receive signal - (differential)
35	GND_RX[3]	GND	3	Ground for receiver
36	FXSD[2]	I	2	Fiber signal detect
37	FXSD[3]	I	3	Fiber signal detect
38	GND_ANA	GND		Analog ground

Note 1. Pwr = power supply
GND = ground
I = input
O = output
I/O = bi-directional

Pin Number	Pin Name	Type(Note 1)	Port	Pin Function
39	TEST[1]	I		Factory test pin
40	TEST[2]	I		Factory test pin
41	GND_RCV[2]	GND	2	Ground for clock recovery circuitry
42	VDD_RCV[2]	Pwr	2	2.5V for clock recovery circuitry
43	GND_RCV[3]	GND	3	Ground for clock recovery circuitry
44	VDD_RCV[3]	P	3	2.5V for clock recovery circuitry
45	VMDIS	I		DIScard VLAN Mismatch packets
46	FFLOW2#	I	2	Force flow control on port 2
47	PV32	I	3	Port 3 VLAN Port mask bit 1
48	PV31	I	3	Port 3 VLAN Port mask bit 0
49	PV23	I	2	Port 2 VLAN Port mask bit 2
50	FFLOW1#	I	1	Force flow control on port 1
51	PV21	I	2	Port 2 VLAN Port mask bit 0
52	PV13	I	1	Port 1 VLAN Port mask bit 2
53	PV12	I	1	Port 1 VLAN Port mask bit 1
54	DISAN3	I	3	Port 3 auto-negotiation disable (pull this down to enable port 3 auto negotiation)
55	VDD	Pwr		2.5V for core digital circuitry
56	GND	GND		Ground for digital circuitry
57	MTXEN	I	3	MII transmit enable
58	MTXD[3]	I	3	MII transmit bit 3
59	MTXD[2]	I	3	MII transmit bit 2
60	MTXD[1]	I	3	MII transmit bit 1
61	MTXD[0]	I	3	MII transmit bit 0
62	MTXER	I	3	MII transmit error
63	MTXCLK	I/O	3	MII output clock
64	MRXDV	O	3	MII receive data valid
65	MRXD[3]	O	3	MII receive bit 3
66	MRXD[2]	O	3	MII receive bit 2
67	MRXD[1]	O	3	MII receive bit 1
68	MRXD[0]	O	3	MII receive bit 0
69	VDD_IO	Pwr		2.5V or 3.3V for MII interface, LEDs and other digital I/O
70	GND	GND		Ground for digital circuitry
71	MRXCLK	I/O	3	MII input clock
72	MCOL	O	3	MII collision detect output
73	MCRS	I/O	3	MII carrier sense
74	MCOLIN	I	3	MII collision detect input
75	MIIS[1]	I	3	MII mode select bit 1
76	MIIS[0]	I	3	MII mode select bit 0

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GND = ground
I = input
O = output
I/O = bi-directional

Pin Number	Pin Name	Type(Note 1)	Port	Pin Function
77	MODESEL[3]	I		Selects LED and test modes
78	MODESEL[2]	I		Selects LED and test modes
79	MODESEL[1]	I		Selects LED and test modes
80	MODESEL[0]	I		Selects LED and test modes
81	TESTEN	I		Factory test pin - tie low for normal operation
82	SCANEN	I		Factory test pin - tie low for normal operation
83	RST#	I		Reset
84	VDD	Pwr		2.5V for core digital circuitry
85	GND	GND		Ground for digital circuitry
86	LED[1][3]	O	1	Port 1 LED indicator 3
87	LED[1][2]	O	1	Port 1 LED indicator 2
88	LED[1][1]	O	1	Port 1 LED indicator 1
89	LED[1][0]	O	1	Port 1 LED indicator 0
90	LED[2][3]	O	2	Port 2 LED indicator 3
91	LED[2][2]	O	2	Port 2 LED indicator 2
92	LED[2][1]	O	2	Port 2 LED indicator 1
93	LED[2][0]	O	2	Port 2 LED indicator 0
94	VDD_IO	Pwr		2.5V or 3.3V for MII interface, LEDs and other digital I/O
95	GND	GND		Ground for digital circuitry
96	LED[3][3]	O	3	Port 3 LED indicator 3
97	LED[3][2]	O	3	Port 3 LED indicator 2
98	LED[3][1]	O	3	Port 3 LED indicator 1
99	LED[3][0]	O	3	Port 3 LED indicator 0
100	PRSV	I		Priority queue buffer reserve
101	PRSEL[1]	I		Priority scheme select bit 1
102	PRSEL[0]	I		Priority scheme select bit 0
103	PBASE2	I		Priority base value bit 2
104	PBASE1	I		Priority base value bit 1
105	PBASE0	I		Priority base value bit 0
106	P3_1PEN	I	3	Port 3 802.1p receive priority classification enable
107	P2_1PEN	I	2	Port 2 802.1p receive priority classification enable
108	P1_1PEN	I	1	Port 1 802.1p receive priority classification enable
109	P3_TXQ2	I	3	Port 3 transmit queue split, priority queueing enable
110	P2_TXQ2	I	2	Port 2 transmit queue split, priority queueing enable
111	P1_TXQ2	I	1	Port 1 transmit queue split, priority queueing enable
112	GND	GND		Ground for digital circuitry
113	VDD	Pwr		2.5V for core digital circuitry
114	P3_PP	I	3	Port 3 receive port based priority classification
115	P2_PP	I	2	Port 2 receive port based priority classification

Note 1. Pwr = power supply
GND = ground
I = input
O = output
I/O = bi-directional

Pin Number	Pin Name	Type(Note 1)	Port	Pin Function
116	P1_PP	I	1	Port 1 receive port based priority classification
117	P1_TAGINS	I	1	Port 1 tag insertion enable
118	P2_TAGINS	I	2	Port 2 tag insertion enable
119	P3_TAGINS	I	3	Port 3 tag insertion enable
120	P3_TAGRM	I	3	Port 3 tag removal enable
121	P2_TAGRM	I	2	Port 2 tag removal enable
122	P1_TAGRM	I	1	Port 1 tag removal enable
123	VDD_RCV[1]	Pwr	1	2.5V for clock recovery circuitry
124	GND_RCV[1]	GND	1	Ground for clock recovery circuitry
125	X2	O		Connect to crystal input
126	X1	I		Crystal or clock input
127	FXSD[1]	I	1	Fiber signal detect
128	AOUT	O		Factory test output

Note 1. Pwr = power supply
GND = ground
I = input
O = output
I/O = bi-directional

I/O Grouping

Group Name	Description
PHY	Physical Interface
MII	Media Independant Interface
SNI	Serial Network Interface
IND	LED Indicators
UP	Unmanaged Programmable
CTRL	Control and Miscellaneous
TEST	Test (Factory)
PWR	Power and Ground

I/O Descriptions

Group	I/O Names	Active Status	Description
PHY	RXP[1:3] RXM[1:3]	Analog	Differential inputs (receive) for connection to media (transformer or fiber module).
	TXP[1:3] TXM[1:3]	Analog	Differential outputs (transmit) for connection to media (transformer or fiber module).
	FXSD[1:3]	H	Fiber signal detect - connect to fiber signal detect output on fiber module. Tie low for 100TX mode.
	VREF[1:3]	Analog	Center tap transformer reference for transmit data.
	ISET	Analog	Transmit Current Set. Connecting an external reference resistor to set transmitter output current. This pin connects a 1% 3kΩ resistor if a transformer of turns ratio of 1:1 is used.
MII			See *"Table 2, MII Interconnect"* for forward and reverse signal usage.
	MRXD[0:3]	H	Four bit wide data bus for receiving MAC frames.
	MRXDV	H	Receive data valid.
	MCRS	H	Receive carrier sense.
	MCOL	H	Receive collision detection.
	MCOLIN	H	Collision in (for forward operation only).
	MRXCLK	Clock	Receive clock.
	MTXD[0:3]	H	Four bit wide data bus for transmitting MAC frames.
	MTXEN	H	Transmit enable.
	MTXER	H	Transmit error.
	MTXCLK	Clock	Transmit clock.
SNI	MTXD[0]	H	Serial transmit data.
	MTXEN	H	Transmit enable.
	MTXCLK	Clock	Transmit clock.
	MRXD[0]	H	Serial receive data.
	MRXDV	H	Receive carrier sense/data valid.
	MCOL	H	Collision detection.
	MRXCLK	Clock	Receive clock.
IND	LED[1:3][0]	L	Output (after reset). Mode 0: Speed (low = 100/high = 10). Mode 1: Reserved. Mode 2: Collision (toggle = collision during receiving , high = no collision). Mode 3: Speed (low = 100/high = 10).
	LED[1:3][1]	L	Output (after reset). Mode 0: Duplex (low = full/high = half). Mode 1: Duplex (low = full/high = half). Mode 2: Duplex (low = full/high = half). Mode 3: Reserved.
	LED[1:3][2]	L	Output (after reset). Mode 0: Collision (toggle = collision during receiving , high = no collision). Mode 1: Transmit Activity (toggle during transmission, high = idle). Mode 2: 10/link/act (constant low = link, toggle = act, constant high = no link). Mode 3: Full-Duplex + Collision (constant low = full-duplex, toggle = collision in half. duplex, constant high = half-duplex with no collision).

<table>
<tr><th>Group</th><th>I/O Names</th><th>Active Status</th><th>Description</th></tr>
<tr><td></td><td>LED[1:3][3]</td><td>L</td><td>Output (after reset).
Mode 0: Link + Activity (toggle = receiving or transmitting, constant low = link, constant high = no link).
Mode 1: Receive Activity (toggle during receiving / high = no receiving activity).
Mode 2: 100/link/act (constant low = link, toggle = act, constant high = no link).
Mode 3: Mode 3: Link + Activity (toggle = receiving or transmitting, constant low = link, constant high = no link).
Note: Mode is set by MODESEL[3:0] ; please see description in UP “Unmanaged Programming” section.</td></tr>
<tr><td>UP</td><td>MODESEL[3:0]</td><td>H</td><td>Mode select at reset time. LED mode is selected by using the table below. MODESEL also controls the maximum frame length accepted.
<table>
<tr><th colspan="4">MODESEL</th><th></th><th></th></tr>
<tr><th>3</th><th>2</th><th>1</th><th>0</th><th>LED mode</th><th>Max Length (no tag/tag)</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>LED mode 0</td><td>1518/1522</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>LED mode 1</td><td>1518/1522</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>LED mode 2</td><td>1518/1522</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>LED mode 3</td><td>1518/1522</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>LED mode 3</td><td>1536/1536</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>LED mode 0</td><td>1536/1536</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>Factory testing</td><td>Not applicable</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>LED mode 2</td><td>1536 / 1536</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>Factory testing</td><td>Not applicable</td></tr>
</table></td></tr>
<tr><td></td><td>FFLOW1#</td><td>L</td><td>Enable force flow control feature on port 1.
Pulled up = no force flow control feature on port 1 (default).
Flow control feature is enabled and disabled by auto-negotiation.
Pulled down = enable force flow control feature on port 1 regardless of auto-negotiation result.</td></tr>
<tr><td></td><td>FFLOW2#</td><td>L</td><td>Program force flow control feature on port 2.
Pulled up = no force flow control feature on port 2 (default).
Flow control feature is enabled and disabled by auto-negotiation.
Pulled down = enable force flow control feature on port 2 regardless of auto-negotiation result.</td></tr>
<tr><td></td><td>LED[1][3]</td><td></td><td>Program advertise flow control feature for 10/100BaseTX ports during auto-negotiation at reset time.
Pulled low = no advertise flow control during auto-negotiation.
Pulled high = advertise flow control during auto-negotiation (default).</td></tr>
<tr><td></td><td>LED[1][2]</td><td></td><td>Programs force flow control feature on port 3, incuding MII port at reset time.
Pulled low = no force flow control feature on port 3, including MII port (default).
Flow control feature is enabled/disabled by auto-negotiation result.
Pulled high = enable force flow control feature on port 3, including MII port regardless of auto-negotiation result.</td></tr>
<tr><td></td><td>LED[1][1]</td><td></td><td>Reserved - use float configuration.</td></tr>
</table>

<table>
<tr><th>Group</th><th>I/O Names</th><th>Active Status</th><th>Description</th></tr>
<tr><td></td><td>LED[1][0]</td><td></td><td>Programs buffer allocation per port at reset time. Use the following table to select the option.
Pulled low = 170 buffers (default).
Pulled high = adaptive mode.</td></tr>
<tr><td></td><td>LED[2][3]</td><td></td><td>Programs MAC address aging in the address look-up table at reset time. Aging eliminates old entries from the table.
Pulled high = 5 minute aging (default).
Pulled low = disable.</td></tr>
<tr><td></td><td>LED[2][2]</td><td></td><td>Programs back pressure enable at reset time.
Pulled high = enable (default).
Pulled low = disable.</td></tr>
<tr><td></td><td>LED[2][1]</td><td></td><td>Programs aggressive back off in half-duplex at reset time.
Pulled high = enable (default).
Pulled low = disable.</td></tr>
<tr><td></td><td>LED[2][0]</td><td></td><td>Programs no excessive collision drop at reset time.
Pulled high = enable (default).
Pulled low = disable.</td></tr>
<tr><td></td><td>LED[3][3]</td><td></td><td>RESERVED.
Use external pulldown resistor if VDD_IO is 3.3V and LED[3][3] is being used. If VDD_IO is not 3.3V or this LED is not used, then no pull-down is required (floating).</td></tr>
<tr><td></td><td>LED[3][2:0]</td><td></td><td>Programs force 100BaseTX mode at reset time. Use the table below to set this mode on the appropriate port. Assuming the corresponding port auto-negotiation is disabled.
<table>
<tr><th>Signal</th><th>Port</th><th>Force 10BaseTX</th><th>Force 100BaseTX</th></tr>
<tr><td>LED[3][2]</td><td>3</td><td>Pulled low</td><td>Pulled high (default)</td></tr>
<tr><td>LED[3][1]</td><td>2</td><td>Pulled low</td><td>Pulled high (default)</td></tr>
<tr><td>LED[3][0]</td><td>1</td><td>Pulled low</td><td>Pulled high (default)</td></tr>
</table></td></tr>
<tr><td></td><td>MRXD[3:1]</td><td></td><td>Programs force full-duplex mode at reset time. Use the table below to set this mode on the appropriate port. Assuming the corresponding port auto-negotiation is disabled.
<table>
<tr><th>Signal</th><th>Port</th><th>Force Half-Duplex</th><th>Force Full-Duplex</th></tr>
<tr><td>MRXD[3]</td><td>3</td><td>Pulled low (default)</td><td>Pulled high</td></tr>
<tr><td>MRXD[2]</td><td>2</td><td>Pulled low (default)</td><td>Pulled high</td></tr>
<tr><td>MRXD[1]</td><td>1</td><td>Pulled low (default)</td><td>Pulled high</td></tr>
</table></td></tr>
<tr><td></td><td>MRXD0</td><td></td><td>Programs “port 1 auto-negotiation disable” at reset time.
Pulled high = auto-negotiation disable.
Pulled low = auto-negotiation enable (default).</td></tr>
<tr><td></td><td>MCOL</td><td></td><td>Programs “port 2 auto-negotiation disable” at reset time.
Pulled high = auto-negotiation disable.
Pulled low = auto-negotiation enable (default).</td></tr>
<tr><td></td><td>DISAN3</td><td></td><td>Programs “port 3 auto-negotiation disable” at reset time.
Pulled high = auto-negotiation disable (default)
Pulled low = auto-negotiation enable</td></tr>
<tr><td></td><td>MIIS[1:0]</td><td>H</td><td>Selects external MII port operation mode. Use the table below to select the external port mode.
<table>
<tr><th colspan="2">MIIS</th><th rowspan="2">Selection</th></tr>
<tr><th>1</th><th>0</th></tr>
<tr><td>L</td><td>L</td><td>External MII disable (default)</td></tr>
<tr><td>L</td><td>H</td><td>MII reverse mode</td></tr>
<tr><td>H</td><td>L</td><td>MII forward mode</td></tr>
<tr><td>H</td><td>H</td><td>7-wire (SNI) mode</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Group</th><th>I/O Names</th><th>Active Status</th><th>Description</th></tr>
<tr><td></td><td>VMDIS</td><td>H</td><td>VLAN Mismatch Discard control.
Pulled low = Constrict multicast and broadcast packets to VLAN.
Pulled high = Constrict all packets to VLAN (default).</td></tr>
<tr><td></td><td>PRSV</td><td>H</td><td>Reserve priority buffers.
Pulled low = No buffers reserved (default).
Pulled high = Reserve 96 buffers per port for high priority queue.</td></tr>
<tr><td></td><td>PBASE[2:0]</td><td>H</td><td>Priority base value used to compare with priority tag in 802.1p tag. When a packet is received that has a 802.1p tag and 802.1p processing is enabled (Px_1PEN=H), the PBASE value is compared to the tag priority field. If the packet tag is greater than or equal to the PBASE value, the packet is sent to the higher priority transmit queue while tags less than PBASE are sent to the lower priority queue. (default = 100).</td></tr>
<tr><td></td><td>PV12
PV13
PV21
PV23
PV31
PV32</td><td>H</td><td>VLAN mask bits. Used to select which ports are seen from any particular port. Use the table below to select VLAN operation.
P1_V defined as (PV13, PV12, 1)
P2_V defined as (PV23, 1 , PV21)
P3_V defined as (1 , PV32, PV31)
<table>
<tr><th>P[3:1]_V Port</th><th>2</th><th>1</th><th>0</th><th>VLAN State</th></tr>
<tr><td>1</td><td>0
1
1</td><td>1
0
1</td><td>1
1
1</td><td>Ports 1 and 2 in VLAN
Ports 1 and 3 in VLAN
Ports 1, 2 and 3 in VLAN (default)</td></tr>
<tr><td>2</td><td>0
1
1</td><td>1
1
1</td><td>1
0
1</td><td>Ports 1 and 2 in VLAN
Ports 2 and 3 in VLAN
Ports 1, 2 and 3 in VLAN (default)</td></tr>
<tr><td>3</td><td>1
1
1</td><td>0
1
1</td><td>1
0
1</td><td>Ports 1 and 3 in VLAN
Ports 2 and 3 in VLAN
Ports 1, 2 and 3 in VLAN (default)</td></tr>
</table>
Note that a minimum of 2 ports are required for each VLAN. The VLAN configuration is viewed from the receiver perspective. All states not listed above are invalid.</td></tr>
<tr><td></td><td>P[3:1]_1PEN</td><td>H</td><td>Enables 802.1p prioritizing on a per port basis. The enable is from the receive perspective. If the 802.1p processing is disabled or there is no tag, priority is determined by the P[3:1]_PP bit.
Pulled low = Disable 802.1p prioritizing (default).
Pulled high = Enable 802.1p prioritizing.</td></tr>
<tr><td></td><td>P[3:1]_PP</td><td>H</td><td>Selects port receive priority in the absence of 802.1p handling.
Pulled low = Low priority (default).
Pulled high = High priority.</td></tr>
<tr><td></td><td>P[3:1]_TAGINS</td><td>H</td><td>Inserts 802.1p tag in received packets if not already existent. The priority field is set based on the port P[3:1]_PP bit. For the P[3:1]_PP bit tied low, the priority field is set to 000 and for the P[3:1]_PP bit tied high, the priority field is set to 111.
Pulled low = No change to received packet (default).
Pulled high = Insert 802.1p tag.
Note that if P[3:1]_TAGINS and P[3:1]_TAGRM are both set for the same port, there is no change to the packet.</td></tr>
<tr><td></td><td>P[3:1]_TAGRM</td><td>H</td><td>Removes 802.1p tag in received packets if they exist.
Pulled low = No change to received packet (default).
Pulled high = Remove 802.1p tag.
Note that if P[3:1]_TAGINS and P[3:1]_TAGRM are both set for the same port, there is no change to the packet.</td></tr>
<tr><td></td><td>P[3:1]_TXQ2</td><td>H</td><td>Selects transmit queue split on a per port basis. The split sets up high and low priority queues.
Pulled low = Single transmit queue (default)
Pulled high = Separate high and low transmit queues</td></tr>
</table>

Group	I/O Names	Active Status	Description
	PRSEL[1:0]	H	Selects queue servicing if using split transmit queues. Use the table below to select desired servicing. Note that this selection effects all split transmit queue ports in the same way.

PRSEL 1	PRSEL 0	Priority Selection
L	L	Transmit all high priority before low priority (default)
L	H	Transmit high priority at 10:1 ratio
H	L	Transmit high priority at 5:1 ratio
H	H	Transmit high priority at 2:1 ratio

Group	I/O Names	Active Status	Description
CTRL	X1	Clock	External crystal or clock input
	X2	Clock	Used when other polarity of crystal is needed. This is unused for a normal clock input.
	RST#	L	System reset
TEST	TESTEN	H	Factory test input - pull low
	SCANEN	H	Factory test input - pull low
	AOUT	H	Factory test output - leave open
	MUX[1:2]	H	See table below

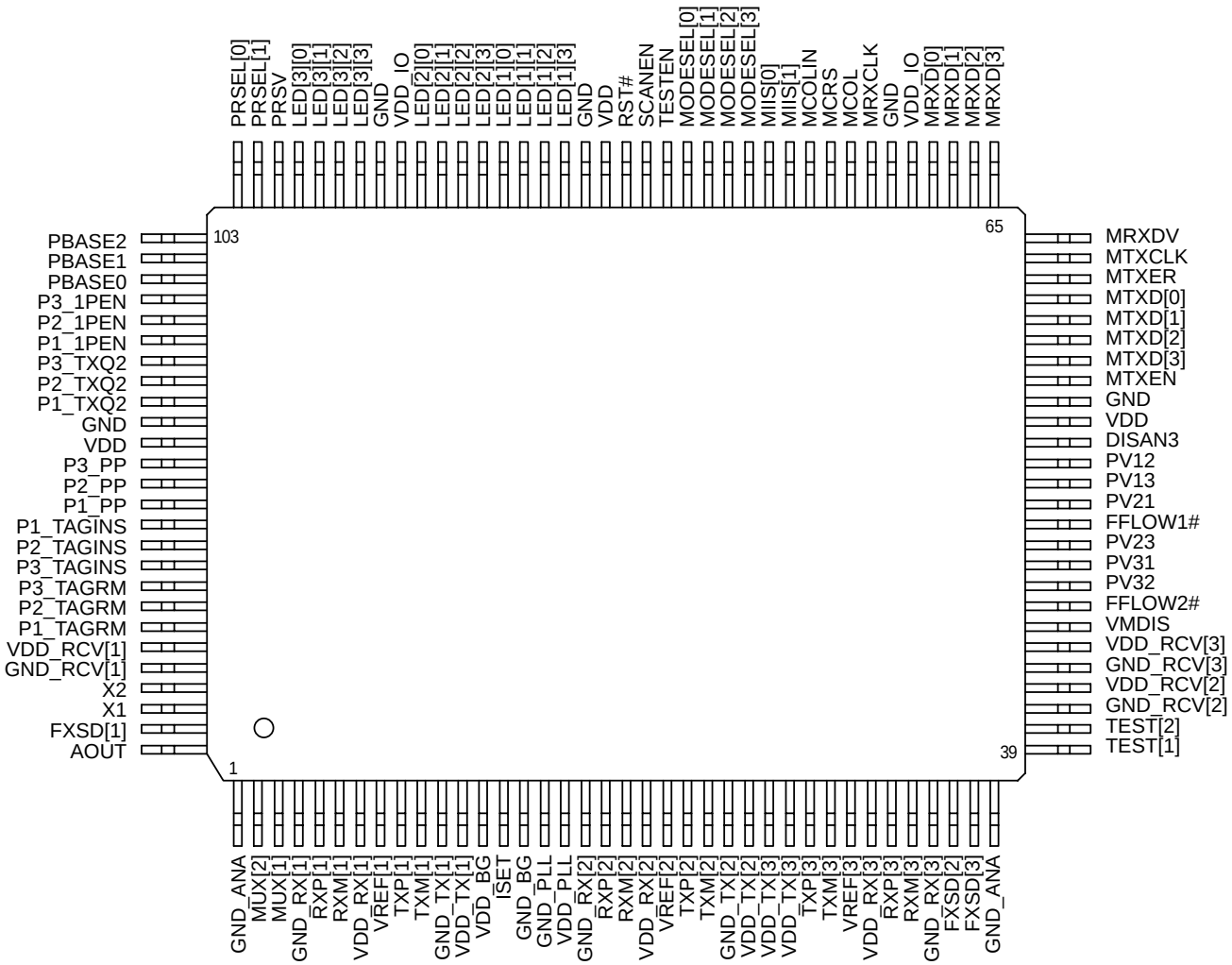
Mux[1]	Mux[2]	
Float	Float	Default for factory test purpose
1	Float	TX Disable Port 1
0	Float	TX Disable Port 2
Float	1	Power Down Port 3
Special note: all other combinations are not allowed		

Group	I/O Names	Active Status	Description
	TEST[1:2]	H	See table below

Test[1]	Test[2]	
Float	Float	Default for factory test purpose
Float	0	Far End Fault Disable
Special note: all other combinations are not allowed .		

Group	I/O Names	Active Status	Description
PWR	VDD_RX[1:3]		2.5V for receiver
	GND_RX[1:3]		Ground for receiver
	VDD_TX[1:3]		2.5V for transmit circuitry
	GND_TX[1:3]		Ground for transmit circuitry
	VDD_RCV[1:3]		2.5V for clock recovery circuitry
	GND_RCV[1:3]		Ground for clock recovery
	VDD_PLL		2.5V for phase locked loop circuitry
	GND_PLL		Ground for phase locked loop circuitry
	GND_ANA		Analog ground
	GND_BG		Analog ground
	VDD_BG		2.5V for analog circuits
	VDD		2.5V for core digital circuitry
	VDD_IO		2.5V or 3.3V for MII interface, LEDs and other digital I/O
	GND		Ground for digital circuitry

Pin Configuration



128-Pin PQFP (PQ)

Functional Overview: Physical Layer Transceiver

100BaseTX Transmit

The 100BaseTX transmit function performs parallel to serial conversion, 4B/5B coding, scrambling, NRZ to NRZI conversion, MLT3 encoding and transmission. The circuit starts with a parallel to serial conversion, which converts the data from the MAC into a 125MHz serial bit stream. The data and control stream is then converted into 4B/5B coding followed by a scrambler. The serialized data is further converted from NRZ to NRZI format, then transmitted in MLT3 current output. The output current is set by an external 1% 3.01kΩ resistor for the 1:1 transformer ratio. It has a typical rise/fall time of 4ns and complies to the ANSI TP-PMD standard regarding amplitude balance, overshoot and timing jitters.

100BaseTX Receive

The 100BaseTX receiver function performs adaptive equalization, DC restoration, MLT3 to NRZI conversion, data and clock recovery, NRZI to NRZ conversion, de-scrambling, 4B/5B decoding and serial to parallel conversion. The receiving side starts with the equalization filter to compensate inter-symbol interference (ISI) over the twisted pair cable. Since the amplitude loss and phase distortion is a function of the length of the cable, the equalizer has to adjust its characteristics to optimize the performance. In this design, the variable equalizer will make an initial estimation based on comparisons of incoming signal strength against some known cable characteristics, then tunes itself for optimization. This is an ongoing process and can self adjust against the environmental changes such as temperature variations.

The equalized signal then goes through a DC restoration and data conversion block. The DC restoration circuit is used to compensate for the effect of base line wander and improve the dynamic range. The differential data conversion circuit converts the MLT3 format back to NRZI. The slicing threshold is also adaptive.

The clock recovery circuit extracts the 125MHz clock from the edges of the NRZI signal. This recovered clock is then used to convert the NRZI signal into the NRZ format. The signal is then sent through the de-scrambler followed by the 4B/5B decoder. Finally, the NRZ serial data is provided as the input data to the MAC.

PLL Clock Synthesizer

The KS8993 generates clocks for the external MII and SNI interface based on the interface type selected.

Scrambler/De-scrambler (100BaseTX only)

The purpose of the scrambler is to spread the power spectrum of the signal in order to reduce EMI and baseline wander. The data is scrambled by the use of an 11-bit wide linear feedback shift register (LFSR). This can generate a 2047-bit non-repetitive sequence. The receiver will then de-scramble the incoming data stream with the same sequence at the transmitter.

100BaseFX Operation

100BaseFX operation is very similar to 100BaseTX operation with the differences being that the scrambler/de-scrambler and MLT3 encoder/decoder are bypassed on transmission and reception. In this mode the auto-negotiation feature is bypassed since there is no standard that supports fiber auto-negotiation.

100BaseFX Signal Detection

The physical port runs in 100BaseFX mode if FXSDx >.6V. This signal is referenced to VREFx which is set at 1/2 Vdd but can be overridden by an external level. VREFx can be connected to the “minus” signal of a differential pair coming from the fiber module (“plus connects to FXSDx) used to convey signal detect. When FXSDx is below .6V then 100BaseFX mode is disabled.

100BaseFX Far End Fault

Far end fault occurs when the signal detection is logically false from the receive fiber module. When this occurs, the transmission side signals the other end of the link by sending 84 1’s followed by a zero in the idle period between frames.

Far End Fault can be disabled by setting external hardware pin TEST[2]=0 and TEST[1] = float. See *“I/O Description”* for pin description.

10BaseT Transmit

The output 10BaseT driver is incorporated into the 100BaseT driver to allow transmission with the same magnetic. They are internally wave-shaped and pre-emphasized into outputs with a typical 2.2V amplitude. The harmonic contents are at least 27dB below the fundamental when driven by an all-ones Manchester-encoded signal.

Special note for 10BaseT operation: With an operating voltage of 2.5V, the KS8993 does not always achieve the specified transmit voltage swing greater than or equal to 2.2V as specified by IEEE 802.3. The important factor however is that the KS8993 does adhere to the specified receive signal voltages using the IEEE twisted pair model with a 100Ω load. The transmit voltage swing can be increased to 2.2V or above by increasing the supply voltage to 2.65V if so desired.

10BaseT Receive

On the receive side, input buffer and level detecting squelch circuits are employed. A differential input receiver circuit and a PLL perform the decoding function. The Manchester-encoded data stream is separated into clock signal and NRZ data. A

squelch circuit rejects signals with levels less than 400mV or with short pulse widths in order to prevent noises at the RXP or RXM input from falsely triggering the decoder. When the input exceeds the squelch limit, the PLL locks onto the incoming signal and the KS8993 decodes a data frame. The receiver clock is maintained active during idle periods in between data reception.

Power Management

Power Save Mode

The KS8993 will turn off everything except for the Energy Detect and PLL circuits when the cable is not installed on an individual port basis. In other words, the KS8993 will shutdown most of the internal circuits to save power if there is no link.

An additional features are available:

Transmit Disable for Port 1 set external pin MUX[1] = 1 and MUX[2] = Float

Transmit Disable for Port 2 set external pin MUX[1] = 0 and MUX[2] = Float

Power Down on Port 3 set external pin MUX[1] = float and MUX[2] = 1

See *"I/O Description"* section for pin description.

LED Mode Selection

Use the following table as a quick reference for setting the LED mode. See MODESEL *"I/O Description"* section for MODESEL[3:2] usage.

MODESEL[1:0]	LED[1:3]3	LED[1:3]2	LED[1:3]1	LED[1:3]0
00	Link + Act	Collision	FDX	Speed
01	RX Act	TX Act	FDX	Reserved
10	100 / Link / Act	10 / Link / Act	FDX	Collision
11	Link + Act	FDX + Collision	Reserved	Speed

Table 1. LED Mode Selection

Auto-Negotiation

The KS8993 conforms to the auto-negotiation protocol as described by the 802.3 committee. Auto-negotiation allows UTP (Unshielded Twisted Pair) link partners to select the best common mode of operation. In auto-negotiation the link partners advertise capabilities across the link to each other. If auto-negotiation is not supported or the link partner to the KS8993 is forced to bypass auto-negotiation, then the mode is set by observing the signal at the receiver. This is known as parallel mode because while the transmitter is sending auto-negotiation advertisements, the receiver is listening for advertisements or a fixed signal protocol.

The flow for the link set up is depicted below.

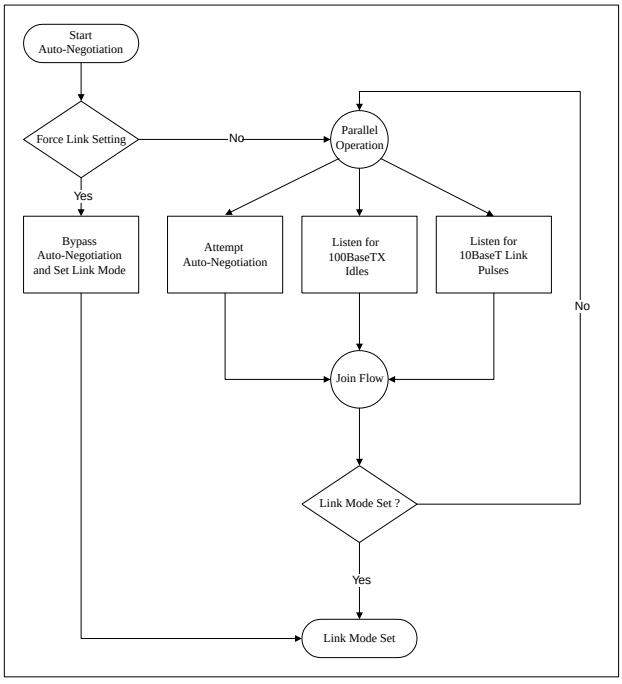


Figure 2. Auto-Negotiation

Functional Overview: Switch Core

Address Look-Up

The internal look-up table stores MAC addresses and their associated information. It contains 1K full CAM with 48-bit address plus switching information. The KS8993 is guaranteed to learn 1K addresses and distinguishes itself from hash-based look-up tables which, depending on the operating environment and probabilities, may not guarantee the absolute number of addresses it can learn.

Learning

The internal look-up engine will update its table with a new entry if the following conditions are met:

- The received packet's SA does not exist in the look-up table.
- The received packet is good; the packet has no receiving errors, and is of legal length.

The look-up engine will insert the qualified SA into the table, along with the port number, time stamp. If the table is full, the last entry of the table will be deleted first to make room for the new entry.

Migration

The internal look-up engine also monitors whether a station is moved. If it happens, it will update the table accordingly. Migration happens when the following conditions are met:

- The received packet's SA is in the table but the associated source port information is different.
- The received packet is good; the packet has no receiving errors, and is of legal length.

The look-up engine will update the existing record in the table with the new source port information.

Aging

The look-up engine will update time stamp information of a record whenever the corresponding SA appears. The time stamp is used in the aging process. If a record is not updated for a period of time, the look-up engine will then remove the record from the table. The look-up engine constantly performs the aging process and will continuously remove aging records. The aging period is approximately 300 seconds ±75 sec. This feature can be enabled or disabled by external pull-up or pull-down resistors. If aging is disabled and look-up table is full, KS8993 will remove the largest address in the table which has been sorted by the binary search.

Forwarding

The KS8993 will forward packets as follows:

- If the DA look-up results is a "match", the KS8993 will use the destination port information to determine where the packet goes.
- If the DA look-up result is a "miss", the KS8993 will forward the packet to all other ports except the port that received the packet.
- All the multicast and broadcast packets will be forwarded to all other ports except the source port.

The KS8993 will not forward the following packets:

- Error packets. These include framing errors, FCS errors, alignment errors, and illegal size packet errors.
- 802.3x pause frames. The KS8993 will intercept these packets and do the appropriate actions.
- "Local" packets. Based on destination address (DA) look-up. If the destination port from the look-up table matches the port where the packet was from, the packet is defined as "local".

Switching Engine

The KS8993 has a very high performance switching engine to move data to and from the MAC's, packet buffers. It operates in store and forward mode, while the efficient switching mechanism reduces overall latency.

The KS8993 has an internal buffer for frames that is 16kx32 (64kB). This resource is shared between the three ports. Buffer sizing per port can be programmed at system reset time by using the unmanaged program mode (I/O strapping).

Each buffer is sized at 128B and therefore there are a total of 512 buffers available. A per port maximum can be set at 170 buffers (equal allocation). There is also an adaptive mode that reacts to port traffic. In the adaptive mode any given port may use up to 256 buffers provided that the other ports are lightly loaded. In the event of heavier loading on other ports the limit is 170 buffers.

MAC (Media Access Controller) Operation

The KS8993 strictly abides by IEEE 802.3 standard to maximize compatibility and interoperability with other vendors.

Inter Packet Gap (IPG)

If a frame is successfully transmitted, the 96 bit time IPG is measured between the two consecutive MTXEN. If the current packet is experiencing collision, the 96 bit time IPG is measured from MCRS and the next MTXEN.

Back off Algorithm

The KS8993 implements the IEEE Std 802.3 binary exponential back-off algorithm, and optional “aggressive mode” back off. After 16 collisions, the packet will be optionally dropped depending on the chip configuration.

Late Collision

If a transmit packet experiences collisions after 512-bit times of the transmission, the packet will be dropped.

Illegal Frames

The KS8993 will discard illegal size frames defined by the IEEE Std 802.3u, including short frames (less than 64 bytes), long frames (greater than 1522 bytes), and FCS error frames. The KS8993 treats VLAN tagged frames as regular frames and does not perform any VLAN related functions. Switches built with the KS8993’s should be treated as a single VLAN domain. KS8993 will drop VLAN frames if the size is larger than 1522 bytes and drop non-VLAN frames if the size is larger than 1518 bytes.

Note that in a special mode, frame lengths of up to 1536 bytes are accepted. This is controlled by MODESEL[3:0]. See *“I/O Descriptions”* section for more details.

Flow Control

KS8993 supports standard 802.3x flow control frames for full-duplex mode and back-pressure for half-duplex.

Full-Duplex Flow Control (IEEE 802.3x standard)

The flow control capabilities of the KS8993 are enabled based upon the results of the auto-negotiation. During the auto-negotiation, 10/100BaseTX port of KS8993 will advertise this feature to the Link Partner. KS8993 will only establish flow control if the Link Partner has the flow control capability. Since 100BaseFX does not support auto-negotiation, 100BaseFX port will not advertise flow control to the Link Partner.

On the receive side, if the KS8993 receives a pause control frame, the KS8993 will not transmit the next normal frame until the timer, specified in the pause control frame, expires. If another pause frame is received before the current timer expires, the timer will be updated with the new value in the second pause frame. During this period (being flow controlled), only flow control packets from the KS8993 will be transmitted.

On the transmit side, the KS8993 has intelligent and efficient ways to determine when to invoke flow control. The flow control is based on availability of the system resources, including available buffers, available transmit queues and available receive queues.

The KS8993 will flow control a port, which just received a packet, if the destination port resource is being used up. The KS8993 will issue a flow control frame (XOFF), containing the maximum pause time defined in IEEE standard 802.3x. Once the resource is freed up, the KS8993 will send out the other flow control frame (XON) with zero pause time to turn off the flow control (turn on transmission to the port). A hysterisis feature is provided to prevent flow control mechanism from being activated and deactivated too many times.

The KS8993 will flow control all ports if the receive queue becomes full.

Take a special note that flow control for 100BaseFX or 10/100BaseTX full-duplex can be forced regardless of auto-negotiation result. This force flow control feature on port 1, 2 or 3 can be enabled and disabled via external pin FFLOW#1, FFLOW#2 and LED[1][2] respectively.

Half-Duplex Back Pressure

Half-duplex Back Pressure option (Note: not in 802.3 standards) is also provided. The activation and deactivation conditions are the same as the above in full-duplex mode. If back pressure is required, the KS8993 will send preambles to defer other stations’ transmission (carrier sense deference). To avoid jabber and excessive deference defined in 802.3 standard, after a certain time it will discontinue the carrier sense but it will raise the carrier sense quickly. This short silent time (no carrier sense) is to prevent other stations from sending out packets and keeps other stations in carrier sense deferred state. If the port has packets to send during a back pressure situation, the carrier sense type back pressure will be interrupted and those packets will be transmitted instead. If there are no more packets to send, carrier sense type back pressure will be active again until switch resources free up. If a collision occurs, the binary exponential back-off algorithm is skipped and carrier sense is generated immediately, reducing the chance of further colliding and maintaining carrier sense to prevent reception of packets. This scheme is better than collision based back pressure.

VLAN Support

Each port is associated with a 3-bit Port VLAN mask register (PV) (P1_V: (PV13, PV12, 1), P2_V: (PV23, 1, PV21), P3_V: (1, PV32, PV31)). Based on the receiving port’s PV, a broadcast packet will be sent to all the ports that have their mask bit set to one, excluding the source port. In other words, broadcast packets will be confined in the VLAN specified in the PV. A unicast packet, which is destined to a port not specified in the PV, could be optionally filtered (depends on the strapped in value during power up, VLAN Mismatch DIScard). The following is a typical set up for a router/switch combo application, in which port 3 is a router port:

P1_V : (1,0,1)

P2_V : (1,1,0)

P3_V : (1,1,1)

In the above setting, there are two VLANs. VLAN 1 includes ports 1,3 and VLAN 2 includes ports 2, 3. Port 3 belongs to both VLANs. If vmdis = 1, port 1 can never talk to port 2. Port 3 has to route all the traffic across the two VLANs. If vmdis = 0 and there are unicast packets, all ports can talk to all others. If vmdis = 0 and there are multicast packets, those packets are confined in the same VLAN. The router can take advantage of the "vmdis = 0" feature, acting as an agent to handle broadcast/multicast protocol, while leaving unicast switching task to KS8993. For example, port 1 sends an "ARP" for the port 2 MAC address. Since port 2 cannot receive the ARP, the attached router on port 3 will act as an agent and report the MAC address of port 2 to port 1. Then all the unicast traffic between port 1 and port 2 could be switched by KS8993, instead of by the router port. This application could enable "wire speed" switching/routing. This feature is sometimes called "leaky VLAN". This leaky VLAN does improve the system performance by separating broadcast domains. Note KS8993 does not support "duplicated MAC addresses" in different VLANs to save MAC table size.

QoS Priority Support

This feature provides QoS for applications such as VOIP, video conferencing, and mission critical applications. The KS8993 per port transmit queue could be split into two priority queues, high priority and low priority queues. The splitting feature could be optionally per port enabled (using pin Px_TXQ2). If a port is split, high priority packets will be put in the high priority queue. If a port's transmit queue is not split, high priority and low priority packets will be treated equally. There are four priority schemes (selected by pins PRSEL1 and PRSEL0): (1), transmit high priority packets always before low priority packets, i.e. A low priority packet could be transmitted only when the high priority queue is empty. (2), 10/1 ratio, transmit a low priority after every 10 high priority packets transmitted if both queues are busy. (3), 5/1 ratio, (4) 2/1 ratio. Incoming packet priority could be classified in two ways, port-based or 802.1p.

Port based priority: Each port could be individually specified as a high priority receiving port (using pin Px_PP). All the packets received at the high priority receiving port will be marked high priority and sent to the high priority transmit queue if the corresponding queue is split.

802.1p based priority: 802.1p based priority could be enabled by pins Px_1PEN. KS8993 will examine incoming packets to determine whether they are tagged and retrieve the corresponding priority information. The priority field in the VLAN tag is 3 bits wide and is compared against "priority base value specified by pins (PBASE[2:0]). If a received packet has an equal or larger priority value than the "priority base" value, the packet will be put in the high priority transmit queue if the corresponding queue is split. KS8993 can optionally remove or insert priority tagged frame's header (2 bytes of tag protocol identifier 0x8100 and 2 bytes of tag control information). If a transmitting port has its corresponding Px_TAGINS set (meaning tag insertion), the transmitting logic will automatically insert "priority tag" for untagged packets with NULL VLAN ID and its priority value (7 for high priority and 0 for low priority). For already tagged packets, KS8993 will pass the original packet without changing its tag content. If a transmitting port has its corresponding Px_TAGRM set (meaning tag removal), the transmitting logic will automatically remove "802.1q tag". For untagged packets, KS8993 will pass the original packet without changing any content. Either tag insertion or removal will cause CRC recalculation.

MII Interface Operation

The MII (Media Independent Interface) operates in either a forward or reverse mode. In the forward mode, the KS8993 MII acts like a MAC and in the reverse mode, it acts like a PHY device. This interface is specified by the IEEE 802.3 committee and provides a common interface between physical layer and MAC layer devices. There are two distinct groups, one being for transmission and the other for receiving. The table below describes the signals used in this interface in forward and reverse modes.

This interface is a nibble wide data interface and therefore runs at 1/4 the network bit rate (not encoded). Additional signals on the transmit side indicate when data is valid or when an error occurs during transmission. Likewise, the receive side has indicators that convey when the data is valid and without physical layer errors.

For half-duplex operation there is a signal that indicates a collision has occurred during transmission.

Note that the signal MRXER is not provided on the MII interface for the KS8993 for reverse operation and MTXER is not represented for forward mode. Normally this would indicate a receive / transmit error coming from the physical layer /MAC device, but is not appropriate for this configuration. If the connecting device has a MRXER pin, this should be tied low on the other device for reverse or if it has a MTXER pin in the forward mode it should also be tied low on the other device.

Reverse MII Mode Connection			**Forward MII Mode Connection**	
External MAC	**KS8993 Signal**	**Description**	**External PHY**	**KS8993 Signal**
MTXEN	MTXEN	Transmit enable	MTXEN	MRXDV
MTXER	MTXER	Transmit error	MTXER	Not used
MTXD3	MTXD[3]	Transmit data bit 3	MTXD3	MRXD[3]
MTXD2	MTXD[2]	Transmit data bit 2	MTXD2	MRXD[2]
MTXD1	MTXD[1]	Transmit data bit 1	MTXD1	MRXD[1]
MTXD0	MTXD[0]	Transmit data bit 0	MTXD0	MRXD[0]
MTXC	MTXCLK	Transmit clock	MTXC	MTXCLK
MCOL	MCOL	Collision detection	MCOL	MCOLIN
MCRS	MCRS	Carrier sense	MCRS	MCRS
MRXDV	MRXDV	Receive data valid	MRXDV	MTXEN
MRXER	Not used	Receive error	MRXER	MTXER
MRXD3	MRXD[3]	Receive data bit 3	MRXD3	MTXD[3]
MRXD2	MRXD[2]	Receive data bit 2	MRXD2	MTXD[2]
MRXD1	MRXD[1]	Receive data bit 1	MRXD1	MTXD[1]
MRXD0	MRXD[0]	Receive data bit 0	MRXD0	MTXD[0]
MRXC	MRXCLK	Receive clock	MRXC	MRXCLK

Table 2. MII Interconnect

SNI Interface (7-wire) Operation

The SNI (Serial Network Interface) is intended to interface with some controllers used for network layer protocol processing. KS8993 acts like a PHY device to external controllers. This interface can be directly connected to these type of devices. The signals are divided into two groups, one being for transmission and the other being the receive side. The signals involved are described in the table below.

This interface is a bit wide data interface and therefore runs at the network bit rate (not encoded). An additional signal on the transmit side indicates when data is valid. Likewise, the receive side has an indicator that conveys when the data is valid.

For half-duplex operation there is a signal that indicates a collision has occurred during transmission.

SNI Signal	Description	KS8993 SNI Signal	KS8993 Input/Output
TXEN	Transmit enable	MTXEN	Input
TXD	Serial transmit data	MTXD[0]	Input
TXC	Transmit clock	MTXCLK	Output
COL	Collision detection	MCOL	Output
CRS	Carrier sense	MRXDV	Output
RXD	Serial receive data	MRXD[0]	Output
RXC	Receive clock	MRXCLK	Output

Table 3. SNI Signal

Absolute Maximum Ratings (Note 1)

Supply Voltage
(V_{DD_RX}, V_{DD_TX}, V_{DD_BG}, V_{DD_PLL}, V_{DD_RCV}, V_{DD}) ..... –0.5V to +3.0V
(V_{DD_IO}) ..... –0.5V to +4.0V
Input Voltage (All Inputs) ..... –0.5V to +4.0V
Output Voltage (All Outputs) ..... –0.5V to +4.0V
Lead Temperature (soldering, 10 sec.) ..... 270°C
Storage Temperature (T_S) ..... –55°C to +150°C

Operating Ratings (Note 2)

Supply Voltage
(V_{DD_RX}, V_{DD_TX}, V_{DD_BG}, V_{DD_PLL}, V_{DD_RCV}, V_{DD}) ..... +2.35V to +2.75V
(V_{DD_IO}) ..... +2.35V to +2.75V or +3.0V to +3.6V
Ambient Temperature (T_A) ..... –0°C to +70°C
Package Thermal Resistance **(Note 3)**
PQFP (θ_{JA}) No Air Flow ..... 42.91°C/W

Electrical Characteristics (Note 4)

V_{DD} = 2.5V to 2.75V; T_A = 0°C to +70°C; unless noted, **bold** values indicate –40°C ≤ T_A ≤ +85°C; unless noted.

Symbol	Parameter	Condition	Min	Typ	Max	Units
Total Supply Current (including TX output driver current)						
I_{DD1}	Normal 100BaseTX			300	330	mA
I_{DD2}	Normal 10BaseT			200	230	mA
TTL Inputs (V_{DDIO} = 3.3V or 2.5V)						
V_{IH}	Input High Voltage		V_{DD} (I/O) –0.8			V
V_{IL}	Input Low Voltage				0.8	V
TTL Outputs (V_{DDIO} = 3.3V or 2.5V)						
V_{OH}	Output High Voltage	I_{OH} = –4mA	V_{DD} (I/O) –0.4			V
V_{OL}	Output Low Voltage	I_{OL} = 4mA			0.4	V
100BaseTX Receive						
	Error Rate				1.0	1E-8
100BaseTX Transmit (measured differentially after 1:1 transformer)						
V_O	Peak Differential Output Voltage	50Ω from each output to V_{DD}	0.95		1.05	V
V_{IMB}	Output Voltage Imbalance	50Ω from each output to V_{DD}		1.5		%
t_r, t_t	Rise/Fall Time		3		5	ns
100BaseTX Transmit (measured differentially after 1:1 transformer)						
V_{SET}	Reference Voltage of ISET			0.75		ns
	Output Jitters	Peak-to-peak		0.7	1.4	ns
10BaseTX Transmit (measured differentially after 1:1 transformer)						
	Near End Normal Link Pulse	V_{DD} = 2.6V	2.2			V
	Far End Normal Link Pulse	After 100 meters Cat-3 cable	0.5			V
	Far End Output Jitters	After 100 meters Cat-3 cable	–8		8	ns

Note 1. Exceeding the absolute maximum rating may damage the device.

Note 2. The device is not guaranteed to function outside its operating rating. Unused inputs must always be tied to an appropriate logic voltage level (Ground to V_{DD}).

Note 3. No HS (heat spreader) in package.

Note 4. Specification for packaged product only.

Timing Diagrams

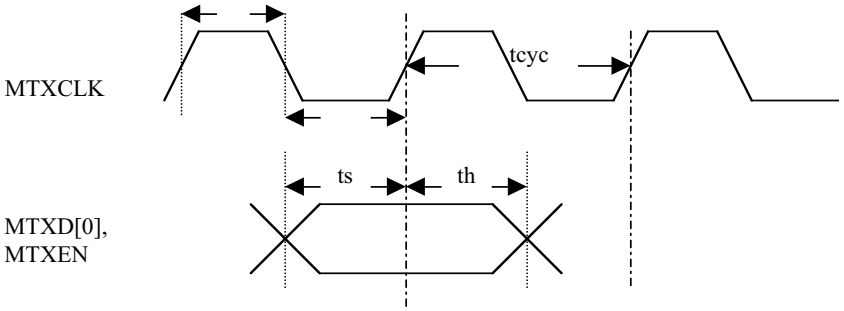


Figure 3. SNI (7-Wire) Input Timing

Symbol	Parameter	Min	Typ	Max	Units
t_{CYC}	Clock Cycle		100		ns
t_S	Set-Up Time	10			ns
t_H	Hold Time	0			ns

Table 4. SNI (7-Wire) Input Timing Parameters

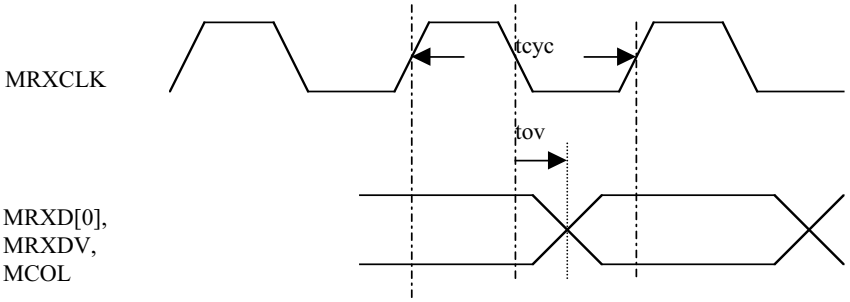


Figure 4. SNI (7-Wire) Output Timing

Symbol	Parameter	Min	Typ	Max	Units
t_{CYC}	Clock Cycle		100		ns
t_{OV}	Output Valid	0	3	6	ns

Table 5. SNI (7-Wire) Output Timing Parameters

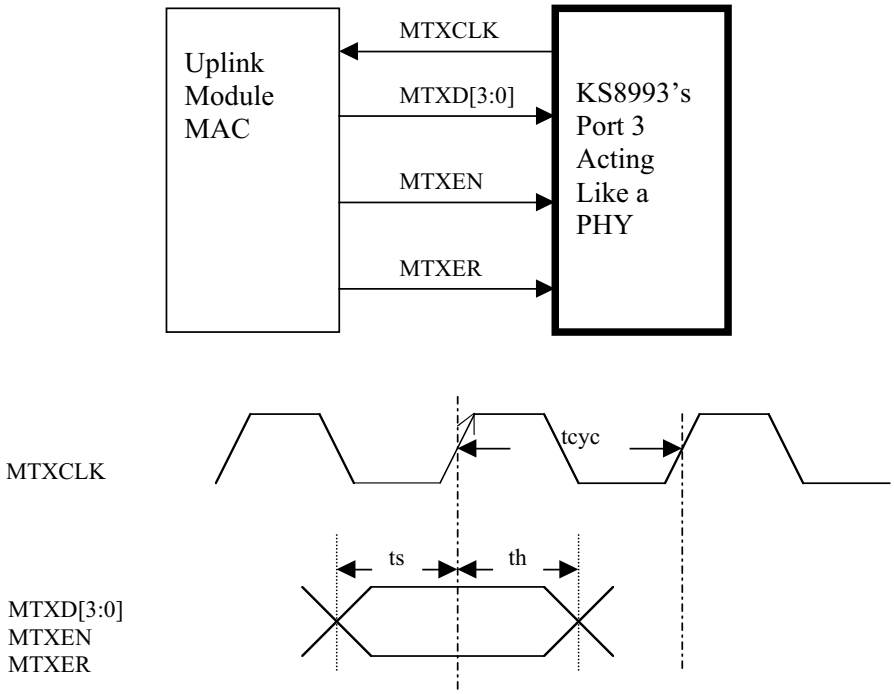


Figure 5. Reverse MII Timing–Receive Data from MII

Symbol	Parameter		Min	Typ	Max	Units
t_{CYC}	Clock Cycle	(100BaseT) (10BaseT)		40 400		ns
t_S	Set-Up Time		10			ns
t_H	Hold Time		0			ns

Table 6. Reverse MII Timing–Receive Data from MII Parameters

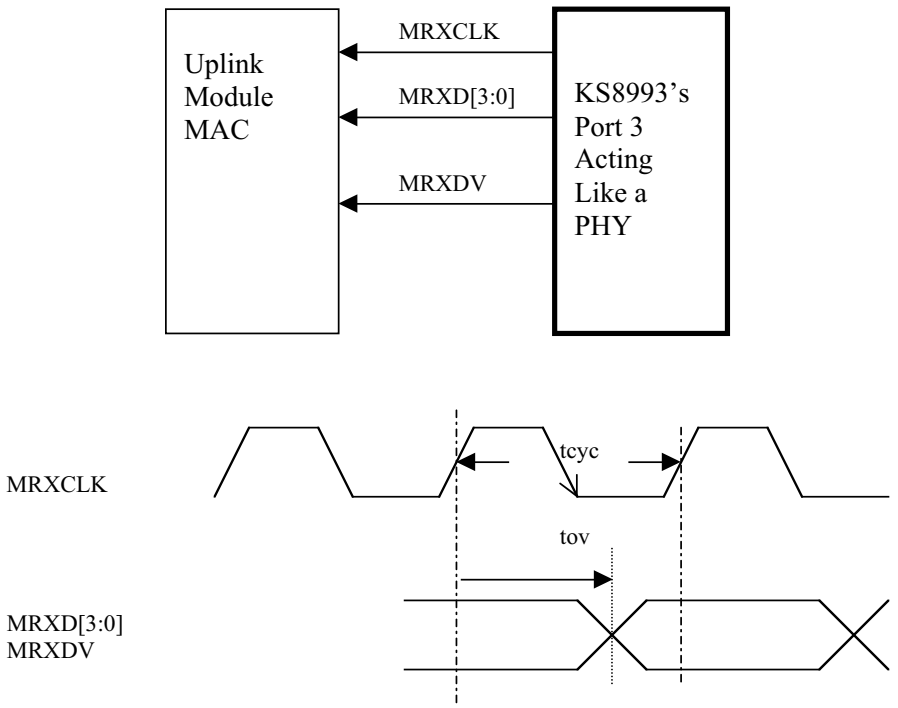


Figure 6. Reverse MII Timing–Transmit Data to MII

Symbol	Parameter		Min	Typ	Max	Units
t_{CYC}	Clock Cycle	(100BaseT) (10BaseT)		40 400		ns
t_{OV}	Output Valid		18	25	28	ns

Table 7. Reverse MII Timing–Transmit Data to MII Parameters

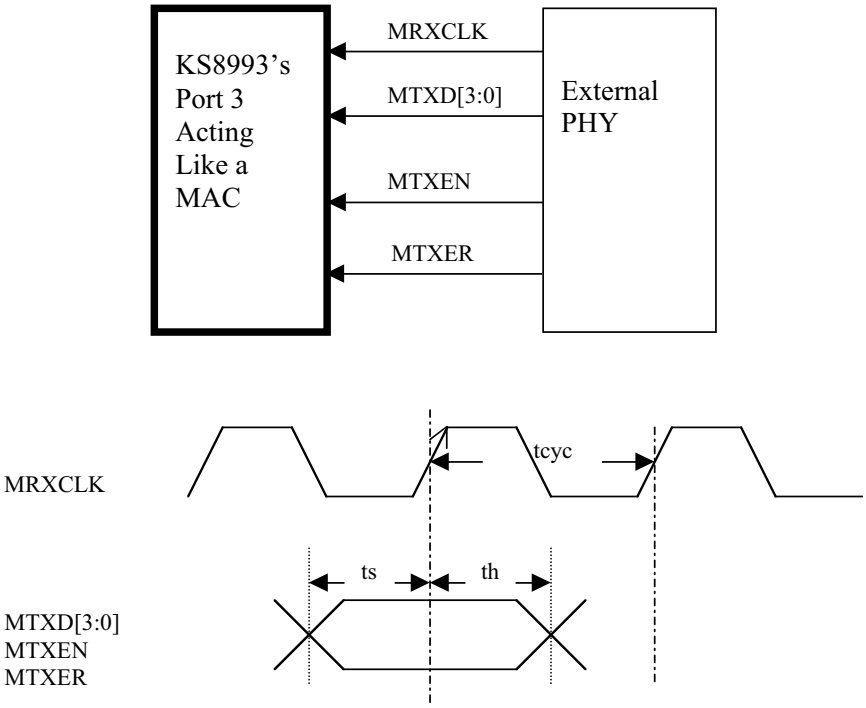


Figure 7. Forward MII Timing–Receive Data from MII

Symbol	Parameter		Min	Typ	Max	Units
t_{CYC}	Clock Cycle	(100BaseT) (10BaseT)		40 400		ns ns
t_S	Set-Up Time		10			ns
t_H	Hold Time		5			ns

Table 8. Forward MII Timing–Receive Data from MII Parameters

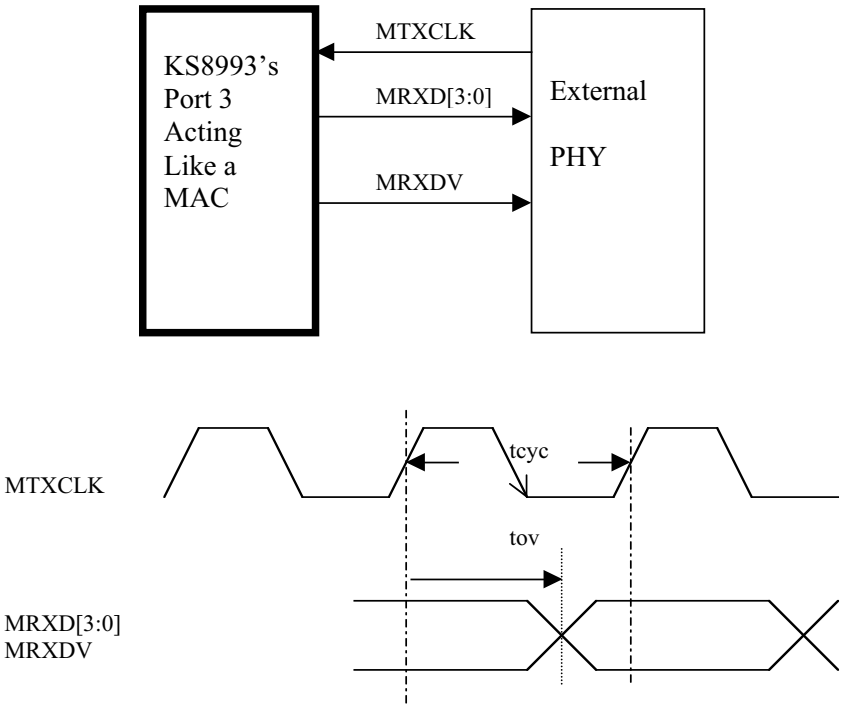


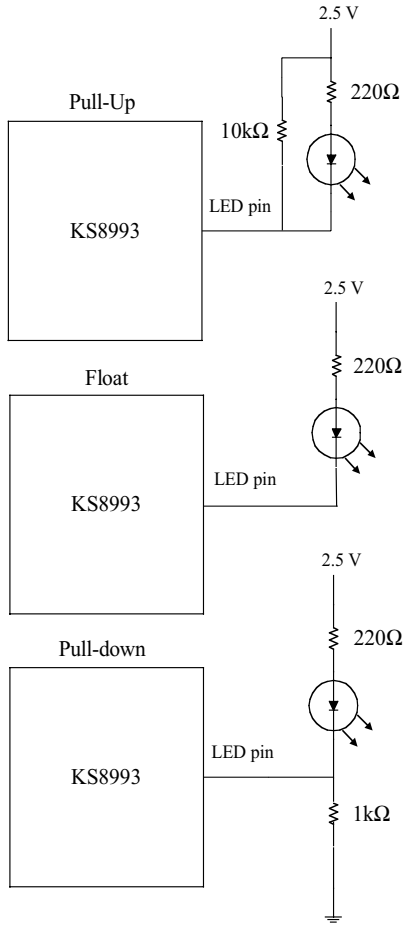
Figure 8. Forward MII Timing–Transmit Data to MII

Symbol	Parameter		Min	Typ	Max	Units
t_{CYC}	Clock Cycle	(100BaseT)		40		ns
		(10BaseT)		400		ns
t_{OV}	Output Valid		7	11	16	ns

Table 9. Forward MII Timing–Transmit Data to MII

Reference Circuit

See *"I/O Description"* section for pull-up/pull-down and float information.



Reference circuits for unmanaged programming through LED ports

Reset Circuit Diagram

Micrel recommendeds the following discrete reset circuit as shown in Figure 9 when powering up the KS8993 device. For the application where the reset circuit signal comes from another device (e.g., CPU, FPGA, etc), we recommend the reset circuit as shown in Figure 10.

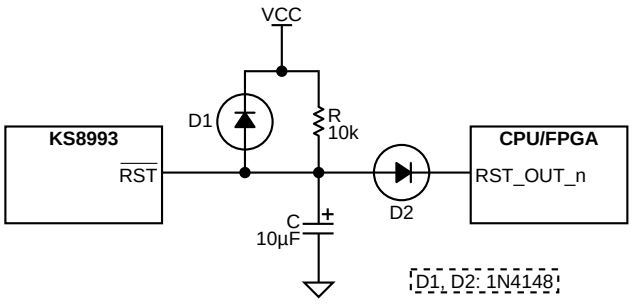


Figure 9. Recommended Reset Circuit.

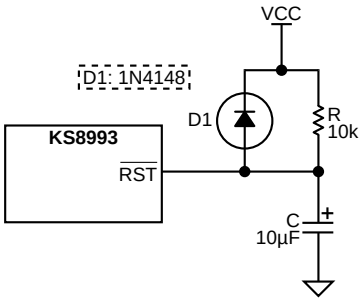


Figure 10. Recommended Circuit for Interfacing with CPU/FPGA Reset

At power-on-reset, R, C, and D1 provide the necessary ramp rise time to reset the Micrel device. The reset out from CPU/FPGA provides warm reset after power up. It is also recommended to power up the VDD core voltage earlier than VDDIO voltage. At worst case, the both VDD core and VDDIO voltages should come up at the same time.

4B/5B Coding

In 100BaseTX and 100BaseFX the data and frame control are encoded in the transmitter (and decoded in the receiver) using a 4B/5B code. The extra code space is required to encode extra control (frame delineation) points. It is also used to reduce run length as well as supply sufficient transitions for clock recovery. The table below provides the translation for the 4B/5B coding.

Code Type	4B Code	5B Code	Value
Data	0000	11110	Data value 0
	0001	01001	Data value 1
	0010	10100	Data value 2
	0011	10101	Data value 3
	0100	01010	Data value 4
	0101	01011	Data value 5
	0110	01110	Data value 6
	0111	01111	Data value 7
	1000	10010	Data value 8
	1001	10011	Data value 9
	1010	10110	Data value A
	1011	10111	Data value B
	1100	11010	Data value C
	1101	11011	Data value D
	1110	11100	Data value E
	1111	11101	Data value F
Control	Not defined	11111	Idle
	0101	11000	Start delimiter part 1
	0101	10001	Start delimiter part 2
	Not defined	01101	End delimiter part 1
	Not defined	00111	End delimiter part 2
	Not defined	00100	Transmit error
Invalid	Not defined	00000	Invalid code
	Not defined	00001	Invalid code
	Not defined	00010	Invalid code
	Not defined	00011	Invalid code
	Not defined	00101	Invalid code
	Not defined	00110	Invalid code
	Not defined	01000	Invalid code
	Not defined	01100	Invalid code
	Not defined	10000	Invalid code
	Not defined	11001	Invalid code

Table 10. 4B/5B Coding

MLT3 Coding

For 100BaseTX operation the NRZI (Non-Return to Zero Invert on ones) signal is line coded as MLT3. The net result of using MLT3 is to reduce the EMI (Electro Magnetic Interference) of the signal over twisted pair media. In NRZI coding, the level changes from high to low or low to high for every “1” bit. For a “0” bit there is no transition. MLT3 line coding transitions through three distinct levels. For every transition of the NRZI signal the MLT3 signal either increments or decrements depending on the current state of the signal. For instance if the MLT3 level is at its lowest point the next two NRZI transitions will change the MLT3 signal initially to the middle level followed by the highest level (second NRZI transition). On the next NRZI change, the MLT3 level will decrease to the middle level. On the following transition of the NRZI signal the MLT3 level will move to the lowest level where the cycle repeats. The diagram below describes the level changes. Note that in the actual 100BaseTX circuit there is a scrambling circuit and that scrambling is not shown in this diagram.

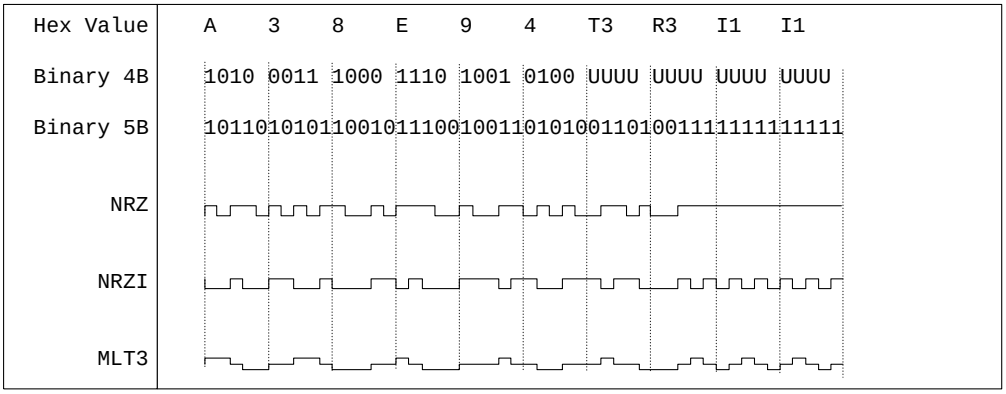


Figure 11. MLT3 coding

The MAC (Media Access Control) fields are described in the table below.

Field	Octect Length	Description
Preamble/SFD	8	Preamble and Start of Frame Delimiter
DA	6	48-bit Destination MAC Address
SA	6	48-bit Source MAC Address
802.1p tag	4	VLAN and priority tag (optional)
Length	2	Frame Length
Protocol/Data	46 to 1500	Higher Layer Protocol and Frame Data
Frame CRC	4	32-bit Cyclical Redundancy Check
ESD	1	End of Stream Delimiter
Idle	Variable	Inter Frame Idles

Table 11. MAC Frame for 802.3

802.1q VLAN and 802.1p Priority Frame

The 3-bit of 802.1p priority is embedded into the 802.1q VLAN frame as described below:

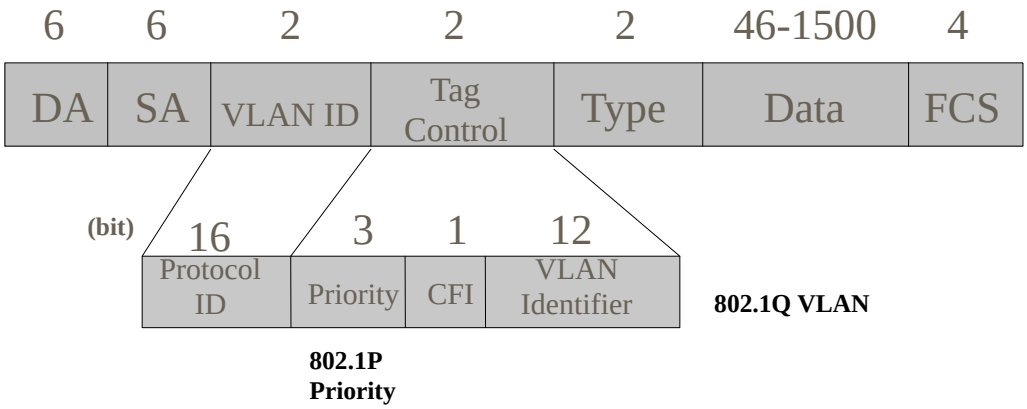


Figure 12. 802.1p and 802.1q Frame Format

Selection of Isolation Transformer(Note 1)

One simple 1:1 isolation transformer is needed at the line interface. An isolation transformer with integrated common-mode choke is recommended for exceeding FCC requirements. The following table gives recommended transformer characteristics.

Characteristics Name	Value	Test Condition
Turns Ratio	1 CT : 1 CT	
Open-Circuit Inductance (min.)	350µH	100mV, 100 KHz, 8mA
Leakage Inductance (max.)	0.4µH	1MHz (min.)
Inter-Winding Capacitance (max.)	12pF	
D.C. Resistance (max.)	0.9Ω	
Insertion Loss (max.)	1.0dB	0MHz to 65MHz
HIPOT (min.)	1500Vrms	

Note 1. The IEEE 802.3u standard for 100BaseTX assumes a transformer loss of 0.5 dB. For the transmit line transformer, insertion loss of up to 1.3dB can be compensated by increasing the line drive current by means of reducing the ISET resistor value.

Selection of Reference Crystal

An oscillator or crystal with the following typical characteristics is recommended.

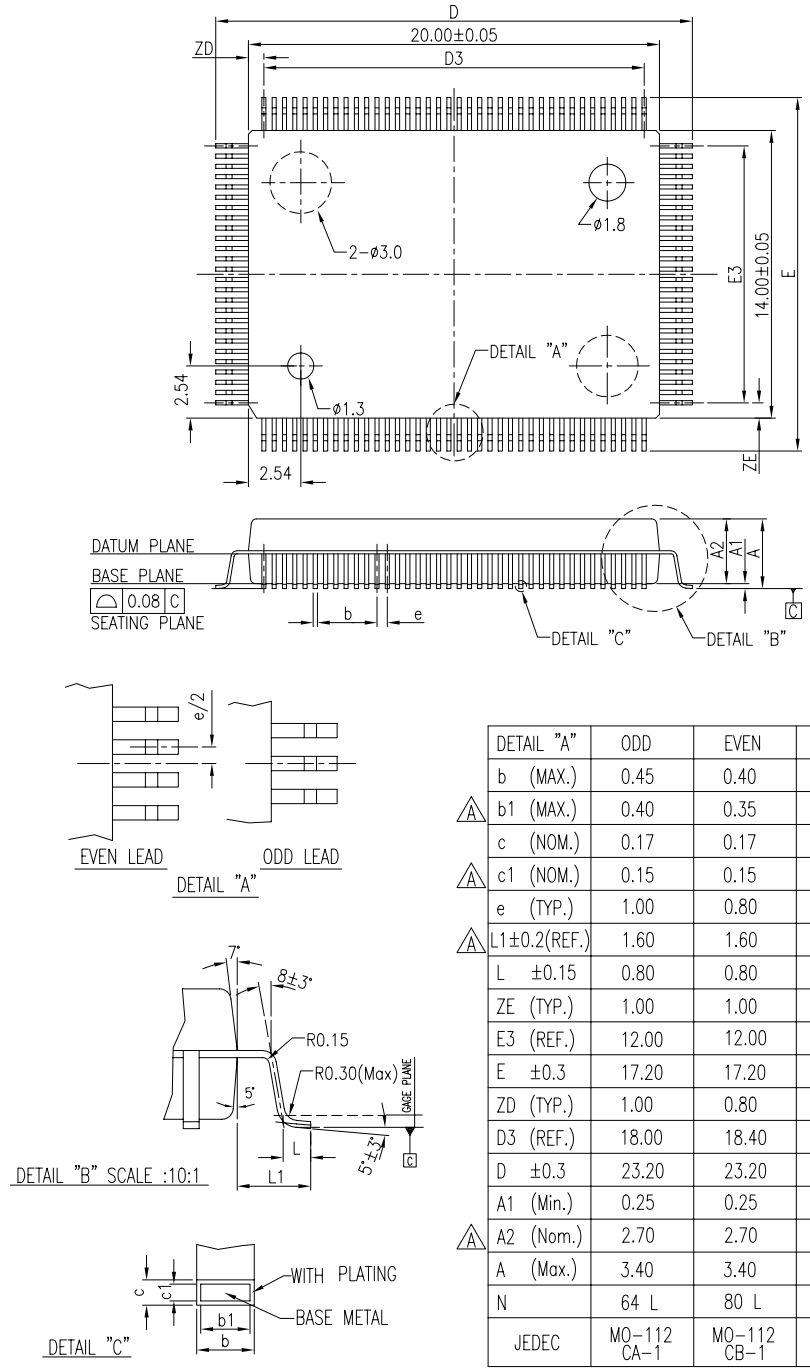
Characteristics Name	Value	Units
Frequency	25.00000	MHz
Frequency Tolerance (max.)	±100	ppm

The following transformer vendors provide pin-to-pin compatible parts for Micrel's device:

Type	Quad		Single	
	Vendor	Part	Vendor	Part
Transformer only	Pulse	H1060	Pulse	H1012
	YCL	PH406080	YCL	20PMT04
	Trans-Power	HB826-10	Trans-Power	HB614-1-LP
Integrated RJ45 and Transformer	Trans-Power	RJG4-754-C-NL	Trans-Power	RJ754-C-NL

Table 12. Qualified Transformer Lists

Package Information



	DETAIL "A"	ODD	EVEN	EVEN	EVEN
	b (MAX.)	0.45	0.40	0.35	0.25
A	b1 (MAX.)	0.40	0.35	0.30	0.20
	c (NOM.)	0.17	0.17	0.17	0.17
A	c1 (NOM.)	0.15	0.15	0.15	0.15
	e (TYP.)	1.00	0.80	0.65	0.50
A	L1±0.2(REF.)	1.60	1.60	1.60	1.60
	L ±0.15	0.80	0.80	0.80	0.80
	ZE (TYP.)	1.00	1.00	0.83	0.75
	E3 (REF.)	12.00	12.00	12.35	12.50
	E ±0.3	17.20	17.20	17.20	17.20
	ZD (TYP.)	1.00	0.80	0.58	0.75
	D3 (REF.)	18.00	18.40	18.85	18.50
	D ±0.3	23.20	23.20	23.20	23.20
	A1 (Min.)	0.25	0.25	0.25	0.25
A	A2 (Nom.)	2.70	2.70	----	----
	A (Max.)	3.40	3.40	3.40	3.40
	N	64 L	80 L	100 L	128L
	JEDEC	MO-112 CA-1	MO-112 CB-1	CC-1	----

128-Pin PQFP (PQ)

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