W5100 Datasheet

Version 1.0.1

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Document History Information

Version	Date	Descriptions
Ver. 1.0.0	Dec. 21, 2006	Release with W5100 Launching
Ver. 1.0.1	Jan. 08, 2007	LB bit in Mode register is not used . W5100 is used only in Big-endian ordering.

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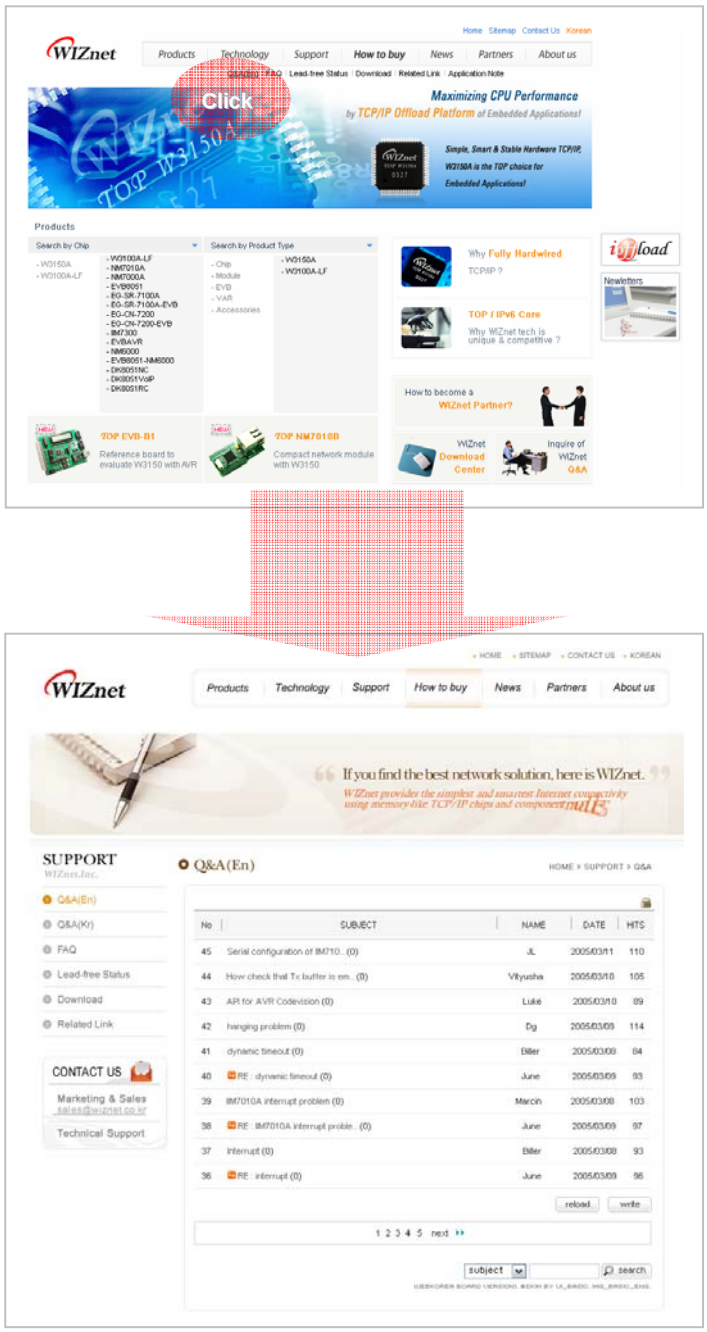


W5100 Datasheet

The W5100 is a full-featured, single-chip Internet-enabled 10/100 Ethernet controller designed for embedded applications where ease of integration, stability, performance, area and system cost control are required. The W5100 has been designed to facilitate easy implementation of Internet connectivity without OS. The W5100 is IEEE 802.3 10BASE-T and 802.3u 100BASE-TX compliant.

The W5100 includes fully hardwired, market-proven TCP/IP stack and integrated Ethernet MAC & PHY. Hardwired TCP/IP stack supports TCP, UDP, IPv4, ICMP, ARP, IGMP and PPPoE which has been proven in various applications for several years. 16Kbytes internal buffer is included for data transmission. No need of consideration for handling Ethernet Controller, but simple socket programming is required.

For easy integration, three different interfaces like memory access way, called direct, indirect bus and SPI, are supported on the MCU side.

Target Applications

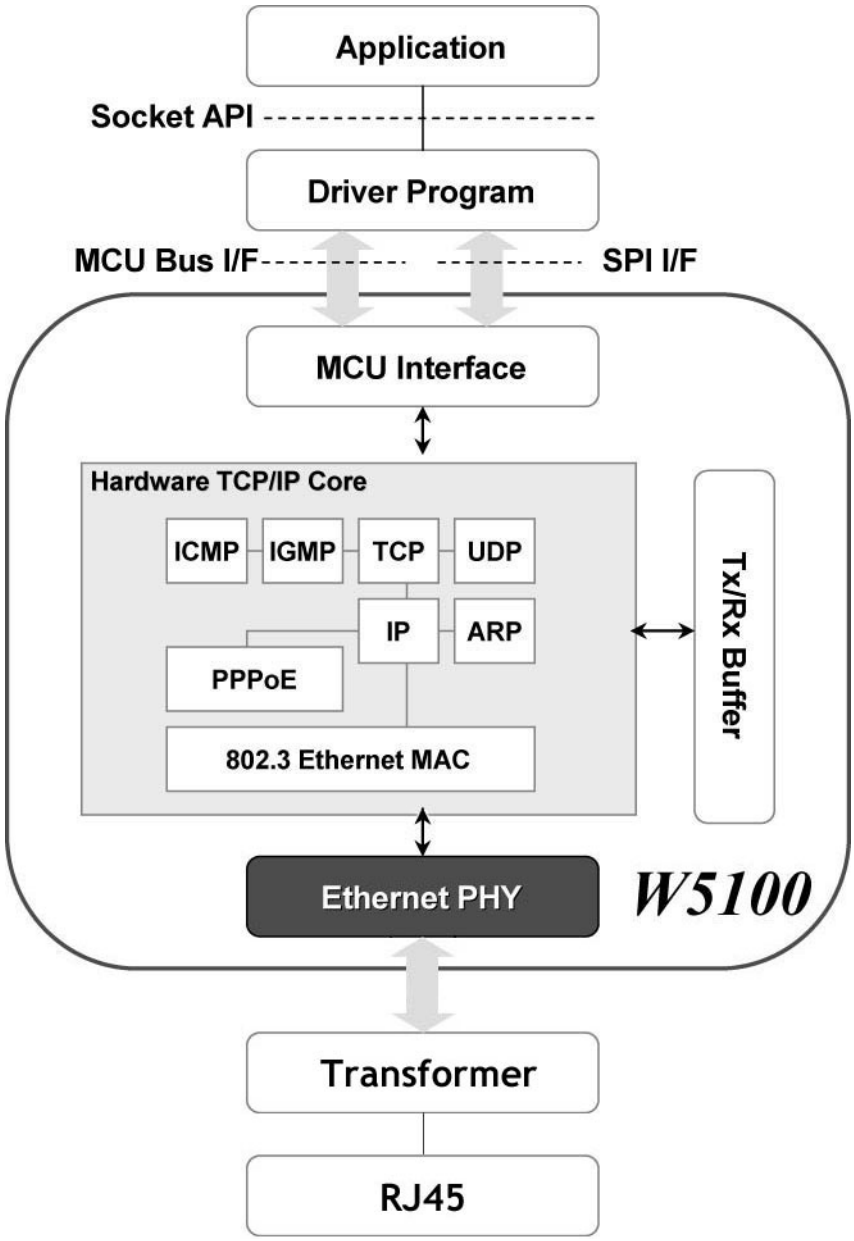
The W5100 is well suited for many embedded applications, including:

- Home Network Devices: Set-Top Boxes, PVRs, Digital Media Adapters
- Serial-to-Ethernet: Access Controls, LED displays, Wireless AP relays, etc.
- Parallel-to-Ethernet: POS / Mini Printers, Copiers
- USB-to-Ethernet: Storage Devices, Network Printers
- GPIO-to-Ethernet: Home Network Sensors
- Security Systems: DVRs, Network Cameras, Kiosks
- Factory and Building Automation
- Medical Monitoring Equipment
- Embedded Servers

Features

- Support Hardwired TCP/IP Protocols : TCP, UDP, ICMP, IPv4 ARP, IGMP, PPPoE, Ethernet
- 10BaseT/100BaseTX Ethernet PHY embedded
- Support Auto Negotiation (Full-duplex and half duplex)
- Support Auto MDI/MDIX
- Support ADSL connection (with support PPPoE Protocol with PAP/CHAP Authentication mode)
- Supports 4 independent sockets simultaneously
- Not support IP Fragmentation
- Internal 16Kbytes Memory for Tx/Rx Buffers
- 0.18 μm CMOS technology
- 3.3V operation with 5V I/O signal tolerance
- Small 80 Pin LQFP Package
- Lead-Free Package
- Support Serial Peripheral Interface(SPI MODE 0, 3)
- Multi-function LED outputs (TX, RX, Full/Half duplex, Collision, Link, Speed)

Block Diagram



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1. Pin Assignment

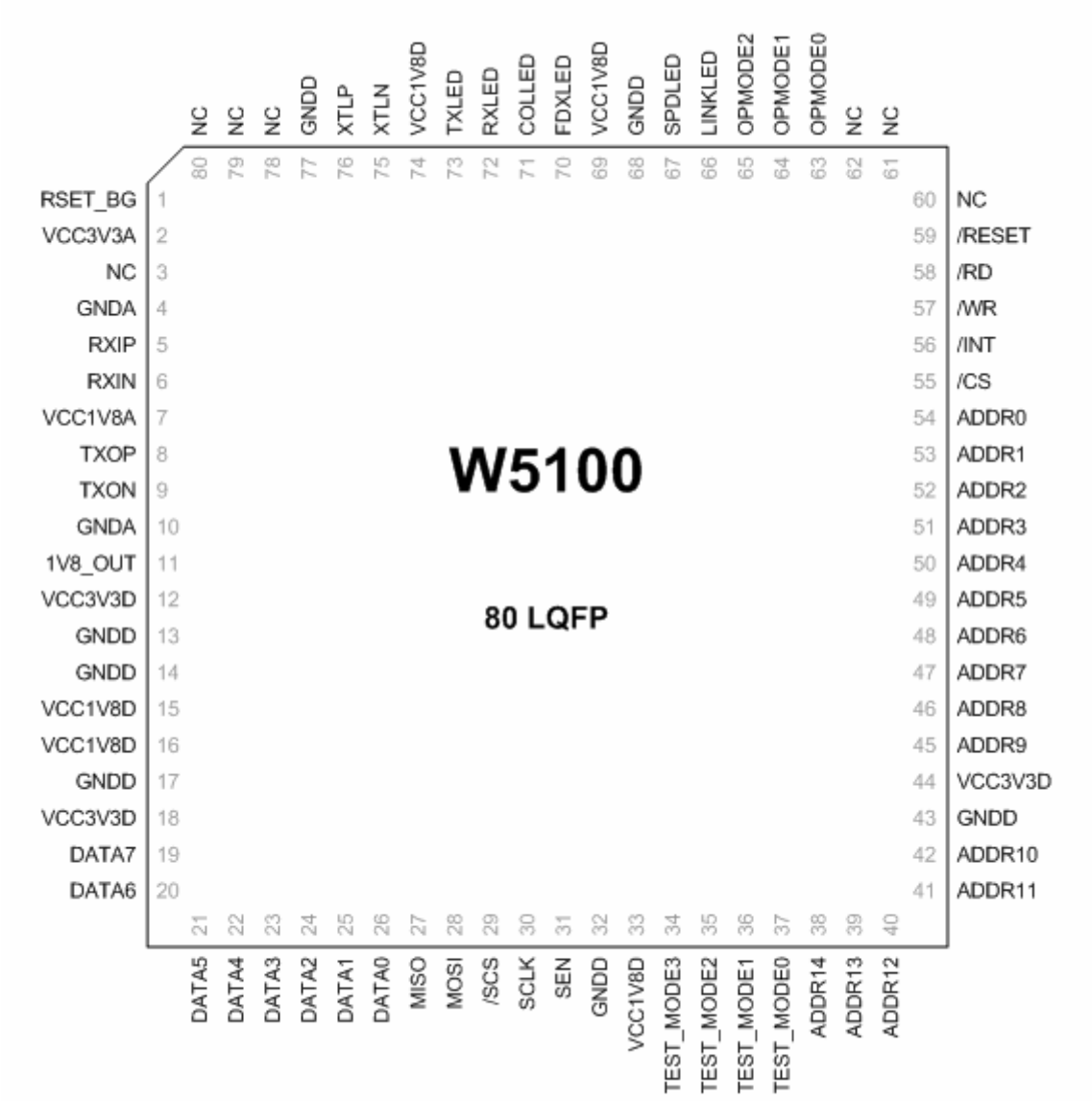


Figure 1. Pinout W5100

1.1 MCU Interface Signals

Symbol	Type	Pin No	Description
/RESET	I	59	RESET This pin is active Low input to initialize or re-initialize W5100. By asserting this pin low for at least 2us, all internal registers will be re-initialized to their default states.
ADDR14-0	I	38, 39, 40, 41, 42, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54	ADDRESS These pins are used to select a register or memory. Address pins are internally pulled down.
DATA7-0	I/O	19, 20, 21, 22, 23, 24, 25, 26	DATA These pins are used to read and write register or memory data.
/CS	I	55	CHIP SELECT Chip Select is for MCU to access to internal registers or memory. /WR and /RD select direction of data transfer. This pin is active low.
/INT	O	56	INTERRUPT This pin Indicates that W5100 requires MCU attention after socket connecting, disconnecting, data receiving or timeout. The interrupt is cleared by writing IR(Interrupt Register) or Sn_IR (Socket nth Interrupt Register). All interrupts are maskable. This pin is active low.
/WR	I	57	WRITE ENABLE Strobe from MCU to write an internal register/memory selected by ADDR[14:0]. Data is latched into the W5100 on the rising edge of this input. This signal is active low.
/RD	I	58	READ ENABLE

			Strobe from MCU to read an internal register/memory selected by ADDR[14:0]. This signal is active low.
SEN	I	31	SPI ENABLE This pin selects Enable/disable of the SPI Mode. Low = SPI Mode Disable High = SPI Mode Enable
SCLK	I	30	SPI CLOCK This pin is used to SPI Clock signal Pin.
/SCS	I	29	SPI SLAVE SELECT This pin is used to SPI Slave Select signal Pin. This pin is active low
MOSI	I	28	SPI MASTER OUT SLAVE IN This pin is used to SPI MOSI signal pin.
MIOS	O	27	SPI MASTER IN SLAVE OUT This pin is used to SPI MISO signal pin.

1.2 PHY Signals

Symbol	Type	Pin No	Description
RXIP	I	5	RXIP/RXIN Signal Pair The differential data from the media is received on the RXIP/RXIN signal pair.
RXIN	I	6	
TXOP	O	8	TXOP/TXON Signal Pair The differential data is transmitted to the media on the TXOP/TXIN signal pair.
TXON	O	9	
RSET_BG	O	1	PHY Off-chip resistor Connect a resistor of 12.3 kΩ±1% to the ground. Refer to the “Reference schematic”.
OPMODE2-0	I	65, 64, 63	OPERATION CONTROL MODE In Auto Negotiation operation mode, tie them to low

1.3 Miscellaneous Signals

Symbol	Type	Pin No	Description
TEST_MODE3-0	I	34, 35, 36, 37	W5100 MODE SELECT Normal mode : 0000 PHY test mode : 1111
NC	I/O	3,60, 61,62, 78,79, 80	NC TEST PIN for W5100 (for factory use only)

1.4 Power Supply Signals

Symbol	Type	Pin No	Description
VCC3A3	Power	2	3.3V power supply for Analog part
VCC3D3	Power	12, 18, 44	3.3V power supply for Digital part
VCC18A	Power	7, 74	1.8V power supply for Analog part
VCC18D	Power	15, 16, 33, 69	1.8V power supply for Digital part
GNDA	Ground	4, 10 77	Analog ground
GNDD	Ground	13, 14, 17, 32, 43, 68,	Digital ground
V18	O	11	1.8V regulator output voltage

1.5 Clock Signals

Symbol	Type	Pin No	Description
XTLP	I	76	25MHz crystal input/output A 25MHz parallel-resonant crystal is used to connect these pins to stabilize the internal oscillator
XTLN	I	75	

1.6 LED Signals

Symbol	Type	Pin No	Description
LINKLED	O	66	Link LED Active low in link state indicates a good status for 10/100M.
SPDLED	O	67	Link speed LED Active low indicates the link speed is 100Mbps.
FDXLED	O	70	Full duplex LED Active low indicates the status of full-duplex mode.
COLLED	O	71	Collision LED Active low indicates the presence of collision activity.
RXLED	O	72	Receive activity LED Active low indicates the presence of receiving activity.
TXLED	O	73	Transmit activity LED Active low indicates the presence of transmitting activity.

2. Memory Map

W5100 is composed of Common Register, Socket Register, TX Memory, and RX Memory as shown below.

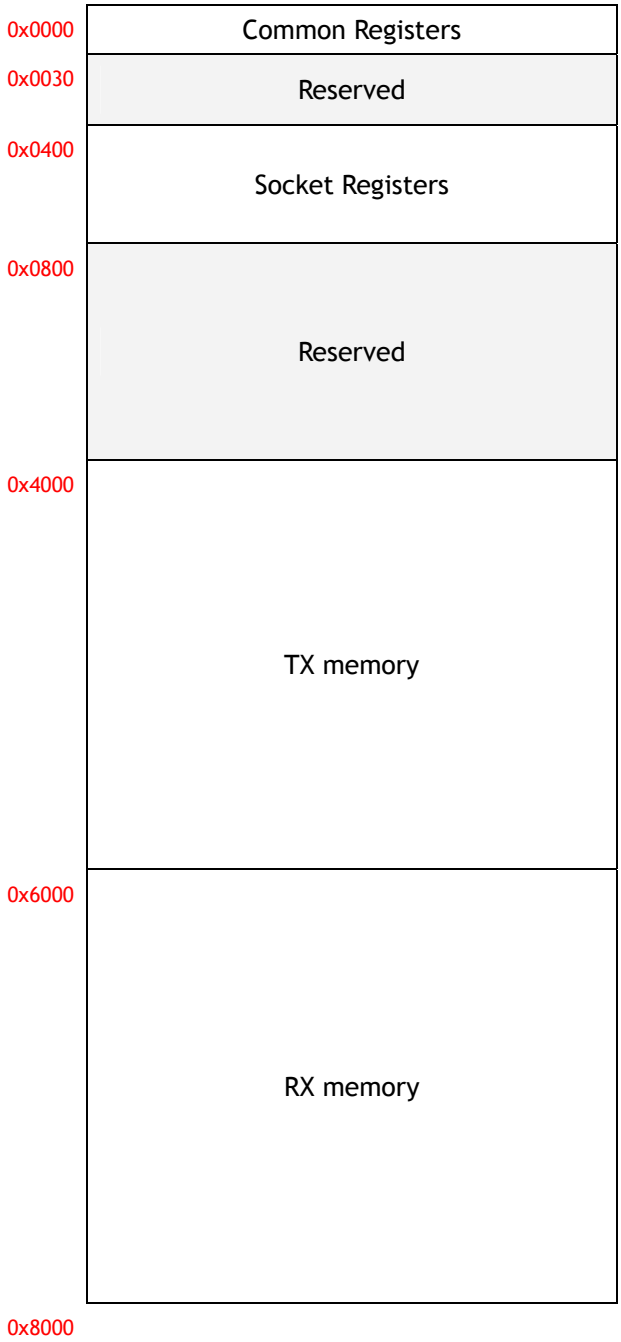


Figure 2. Memory Map

3. W5100 Registers

3.1 common registers

Address	Register
0x0000	Mode (MR)
	Gateway Address
0x0001	(GAR0)
0x0002	(GAR1)
0x0003	(GAR2)
0x0004	(GAR3)
	Subnet mask Address
0x0005	(SUBR0)
0x0006	(SUBR1)
0x0007	(SUBR2)
0x0008	(SUBR3)
	Source Hardware Address
0x0009	(SHAR0)
0x000A	(SHAR1)
0x000B	(SHAR2)
0x000C	(SHAR3)
0x000D	(SHAR4)
0x000E	(SHAR5)
	Source IP Address
0x000F	(SIPR0)
0x0010	(SIPR1)
0x0011	(SIPR2)
0x0012	(SIPR3)
0x0013	Reserved
0x0014	
0x0015	Interrupt (IR)
0x0016	Interrupt Mask (IMR)
	Retry Time
0x0017	(RTR0)
0x0018	(RTR1)
0x0019	Retry Count (RCR)

Address	Register
0x001A	RX Memory Size (RMSR)
0x001B	TX Memory Size (TMSR)
	Authentication Type in PPPoE
0x001C	(PATR0)
0x001D	(PATR1)
0x001E	
~	Reserved
0x0027	
0x0028	PPP LCP Request Timer (PTIMER)
0x0029	PPP LCP Magic number (PMAGIC)
	Unreachable IP Address
0x002A	(UIPR0)
0x002B	(UIPR1)
0x002C	(UIPR2)
0x002D	(UIPR3)
	Unreachable Port
0x002E	(UPORT0)
0x002F	(UPORT1)
0x0030	
~	Reserved
0x03FF	

3.2 Socket registers

Address	Register
0x0400	Socket 0 Mode (S0_MR)
0x0401	Socket 0 Command (S0_CR)
0x0402	Socket 0 Interrupt (S0_IR)
0x0403	Socket 0 Status (S0_SR)
0x0404 0x0405	Socket 0 Source Port (S0_PORT0) (S0_PORT1)
0x0406 0x0407 0x0408 0x0409 0x040A 0x040B	Socket 0 Destination Hardware Address (S0_DHAR0) (S0_DHAR1) (S0_DHAR2) (S0_DHAR3) (S0_DHAR4) (S0_DHAR5)
0x040C 0x040D 0x040E 0x040F	Socket 0 Destination IP Address (S0_DIPR0) (S0_DIPR1) (S0_DIPR2) (S0_DIPR3)
0x0410 0x0411	Socket 0 Destination Port (S0_DPORT0) (S0_DPORT1)
0x0412 0x0413	Socket 0 Maximum Segment Size (S0_MSSR0) (S0_MSSR1)
0x0414	Socket 0 Protocol in IP Raw mode (S0_PROTO)

Address	Register
0x0415	Socket 0 IP TOS (S0_TOS)
0x0416	Socket 0 IP TTL (S0_TTL)
0x0417 ~ 0x041F	Reserved
0x0420 0x0421	Socket 0 TX Free Size (S0_TX_FSR0) (S0_TX_FSR1)
0x0422 0x0423	Socket 0 TX Read Pointer (S0_TX_RD0) (S0_TX_RD1)
0x0424 0x0425	Socket 0 TX Write Pointer (S0_TX_WR0) (S0_TX_WR1)
0x0426 0x0427	Socket 0 RX Received Size (S0_RX_RSR0) (S0_RX_RSR1)
0x0428 0x0429	Socket 0 RX Read Pointer (S0_RX_RD0) (S0_RX_RD1)
0x042A 0x042B	Reserved
0x042C ~ 0x04FF	Reserved

Address	Register
0x0500	Socket 1 Mode (S1_MR)
0x0501	Socket 1 Command (S1_CR)
0x0502	Socket 1 Interrupt (S1_IR)
0x0503	Socket 1 Status (S1_SR)

Address	Register
0x0515	Socket 1 IP TOS (S1_TOS)
0x0516	Socket 1 IP TTL (S1_TTL)

	Socket 1 Source Port
0x0504	(S1_PORT0)
0x0505	(S1_PORT1)
	Socket 1 Destination Hardware Address
0x0506	(S1_DHAR0)
0x0507	(S1_DHAR1)
0x0508	(S1_DHAR2)
0x0509	(S1_DHAR3)
0x050A	(S1_DHAR4)
0x050B	(S1_DHAR5)
	Socket 1 Destination IP Address
0x050C	(S1_DIPR0)
0x050D	(S1_DIPR1)
0x050E	(S1_DIPR2)
0x050F	(S1_DIPR3)
	Socket 1 Destination Port
0x0510	(S1_DPORT0)
0x0511	(S1_DPORT1)
	Socket 1 Maximum Segment Size
0x0512	(S1_MSSR0)
0x0513	(S1_MSSR1)
	Socket 1 Protocol in IP Raw mode
0x0514	(S1_PROTO)

0x0517	
~	Reserved
0x051F	
	Socket 1 TX Free Size
0x0520	(S1_TX_FSR0)
0x0521	(S1_TX_FSR1)
	Socket 1 TX Read Pointer
0x0522	(S1_TX_RD0)
0x0523	(S1_TX_RD1)
	Socket 1 TX Write Pointer
0x0524	(S1_TX_WR0)
0x0525	(S1_TX_WR1)
	Socket 1 RX Received Size
0x0526	(S1_RX_RSR0)
0x0527	(S1_RX_RSR1)
	Socket 1 RX Read Pointer
0x0528	(S1_RX_RD0)
0x0529	(S1_RX_RD1)
0x052A	Reserved
0x052B	
0x052C	
~	Reserved
0x05FF	

Address	Register
0x0600	Socket 2 Mode (S2_MR)
0x0601	Socket 2 Command (S2_CR)
0x0602	Socket 2 Interrupt (S2_IR)
0x0603	Socket 2 Status (S2_SR)
	Socket 2 Source Port
0x0604	(S2_PORT0)
0x0605	(S2_PORT1)

Address	Register
0x0615	Socket 2 IP TOS (S2_TOS)
0x0616	Socket 2 IP TTL (S2_TTL)
0x0617	
~	Reserved
0x061F	
	Socket 2 TX Free Size
0x0620	(S2_TX_FSR0)
0x0621	(S2_TX_FSR1)
	Socket 2 TX Read Pointer
0x0622	(S2_TX_RD0)
0x0623	(S2_TX_RD1)

	Socket 2 Destination Hardware Address
0x0606	(S2_DHAR0)
0x0607	(S2_DHAR1)
0x0608	(S2_DHAR2)
0x0609	(S2_DHAR3)
0x060A	(S2_DHAR4)
0x060B	(S2_DHAR5)
	Socket 2 Destination IP Address
0x060C	(S2_DIPR0)
0x060D	(S2_DIPR1)
0x060E	(S2_DIPR2)
0x060F	(S2_DIPR3)
	Socket 2 Destination Port
0x0610	(S2_DPORT0)
0x0611	(S2_DPORT1)
	Socket 2 Maximum Segment Size
0x0612	(S2_MSSR0)
0x0613	(S2_MSSR1)
	Socket 2 Protocol in IP Raw mode
0x0614	(S2_PROTO)

	Socket 2 TX Write Pointer
0x0624	(S2_TX_WR0)
0x0625	(S2_TX_WR1)
	Socket 2 RX Received Size
0x0626	(S2_RX_RSR0)
0x0627	(S2_RX_RSR1)
	Socket 2 RX Read Pointer
0x0628	(S2_RX_RD0)
0x0629	(S2_RX_RD1)
0x062A	Reserved
0x062B	
0x062C	
~	Reserved
0x06FF	

Address	Register
0x0700	Socket 3 Mode (S3_MR)
0x0701	Socket 3 Command (S3_CR)
0x0702	Socket 3 Interrupt (S3_IR)
0x0703	Socket 3 Status (S3_SR)
	Socket 3 Source Port
0x0704	(S3_PORT0)
0x0705	(S3_PORT1)
	Socket 3 Destination Hardware Address
0x0706	(S3_DHAR0)
0x0707	(S3_DHAR1)
0x0708	(S3_DHAR2)
0x0709	(S3_DHAR3)
0x070A	(S3_DHAR4)
0x070B	(S3_DHAR5)

Address	Register
0x0715	Socket 3 IP TOS (S3_TOS)
0x0716	Socket 3 IP TTL (S3_TTL)
0x0717	
~	Reserved
0x071F	
	Socket 3 TX Free Size
0x0720	(S3_TX_FSR0)
0x0721	(S3_TX_FSR1)
	Socket 3 TX Read Pointer
0x0722	(S3_TX_RD0)
0x0723	(S3_TX_RD1)
	Socket 3 TX Write Pointer
0x0724	(S3_TX_WR0)
0x0725	(S3_TX_WR1)

	Socket 3 Destination IP Address
0x070C	(S3_DIPR0)
0x070D	(S3_DIPR1)
0x070E	(S3_DIPR2)
0x070F	(S3_DIPR3)
	Socket 3 Destination Port
0x0710	(S3_DPORT0)
0x0711	(S3_DPORT1)
	Socket 3 Maximum Segment Size
0x0712	(S3_MSSR0)
0x0713	(S3_MSSR1)
	Socket 3 Protocol in IP Raw mode
0x0714	(S3_PROTO)

	Socket 3 RX Received Size
0x0726	(S3_RX_RSR0)
0x0727	(S3_RX_RSR1)
	Socket 3 RX Read Pointer
0x0728	(S3_RX_RD0)
0x0729	(S3_RX_RD1)
0x072A	Reserved
0x072B	
0x072C	
~	Reserved
0x07FF	

4. Register Descriptions

4.1 Common Registers

MR (Mode Register) [R/W] [0x0000] [0x00]

This register is used for S/W reset, memory test mode, ping block mode, PPPoE mode and Indirect bus I/F.

7	6	5	4	3	2	1	0
RST			PB	PPPoE	LB	AI	IND

Bit	Symbol	Description
7	RST	**S/W Reset** If this bit is '1', internal register will be initialized. It will be automatically cleared after reset.
6	Reserved	Reserved
5	Reserved	Reserved
4	PB	**Ping Block Mode** 0 : Disable Ping block 1 : Enable Ping block

		If the bit is set as '1', there is no response to the ping request.
3	PPPoE	**PPPoE Mode** 0 : Disable PPPoE mode 1 : Enable PPPoE mode If you use ADSL without router or etc, you should set the bit as '1' to connect to ADSL Server. For more detail, refer to the application note, *"How to connect ADSL"*.
2	Not Used	Not Used
1	AI	**Address Auto-Increment in Indirect Bus I/F** 0 : Disable auto-increment 1 : Enable auto-increment At the Indirect Bus I/F mode, if this bit is set as '1', the address will be automatically increased by 1 whenever read and write are performed. For more detail, refer to "6.2 Indirect Bus IF Mode".
0	IND	**Indirect Bus I/F mode** 0 : Disable Indirect bus I/F mode 1 : Enable Indirect bus I/F mode If this bit is set as '1', Indirect BUS I/F mode is set. For more detail, refer to "6. Application Information", "6.2 Indirect Bus IF Mode".

GWR (Gateway IP Address Register) [R/W] [0x0001 – 0x0004] [0x00]

This Register sets up the default gateway address.

Ex) in case of "192.168.0.1"

0x0001	0x0002	0x0003	0x0004
192 (0xC0)	168 (0xA8)	0 (0x00)	1 (0x01)

SUBR (Subnet Mask Register) [R/W] [0x0005 – 0x0008] [0x00]

This register sets up the subnet mask address.

Ex) in case of "255.255.255.0"

0x0005	0x0006	0x0007	0x0008
255 (0xFF)	255 (0xFF)	255 (0xFF)	0 (0x00)

SHAR (Source Hardware Address Register) [R/W] [0x0009 – 0x000E] [0x00]

This register sets up the Source Hardware address.

Ex) In case of "00.08.DC.01.02.03"

0x0009	0x000A	0x000B	0x000C	0x000D	0x000E

0x00	0x08	0xDC	0x01	0x02	0x03

SIPR (Source IP Address Register) [R/W] [0x000F – 0x0012] [0x00]

This register sets up the Source IP address.

Ex) in case of "192.168.0.3"

0x000F	0x0010	0x0011	0x0012
192 (0xC0)	168 (0xA8)	0 (0x00)	3 (0x03)

IR (Interrupt Register) [R] [0x0015] [0x00]

This register is accessed by the host processor to know the cause of an interrupt.

Any interrupt can be masked in the Interrupt Mask Register (IMR). The /INT signal retain low as long as any masked signal is set, and will not go high until all masked bits in this Register have been cleared.

7	6	5	4	3	2	1	0
CONFLICT	UNREACH	PPPoE	Reserved	S3_INT	S2_INT	S1_INT	S0_INT

Bit	Symbol	Description
7	CONFLICT	**IP Conflict** It is set as '1', when there is ARP request with same IP address as Source IP address. This bit is cleared to '0' by writing '1' to this bit.
6	UNREACH	**Destination unreachable** W5100 will receive ICMP(Destination Unreachable) packet if non-existing destination IP address is transmitted during UDP data transmission. (Refer to "5.2.2 UDP"). In this case, the IP address and the port number will be saved in Unreachable IP Address (UIPR) and Unreachable Port Register (UPORT), and the bit will be set as '1'. This bit will be cleared to '0' by writing '1' to this bit.
5	PPPoE	**PPPoE Connection Close** In the PPPoE Mode, if the PPPoE connection is closed, '1' is set. This bit will be cleared to '0' by writing '1' to this bit.
4	Reserved	Reserved
3	S3_INT	**Occurrence of Socket 3 Socket Interrupt** It is set in case that interrupt occurs at the socket 3. For more detailed information of socket interrupt, refer to "Socket 3 Interrupt Register (S3_IR)". This bit will be automatically cleared when S3_IR is cleared to

		0x00.
2	S2_INT	**Occurrence of Socket 2 Socket Interrupt** It is set in case that interrupt occurs at the socket 2. For more detailed information of socket interrupt, refer to "Socket 2 Interrupt Register(S2_IR)". This bit will be automatically cleared when S2_IR is cleared to 0x00.
1	S1_INT	**Occurrence of Socket 1 Socket Interrupt** It is set in case that interrupt occurs at the socket 1. For more detailed information of socket interrupt, refer to "Socket 1 Interrupt Register (S1_IR)". This bit will be automatically cleared when S1_IR is cleared to 0x00.
0	S0_INT	**Occurrence of Socket 0 Socket Interrupt** It is set in case that interrupt occurs at the socket 0. For more detailed information of socket interrupt, refer to "Socket 0 Interrupt Register (S0_IR)". This bit will be automatically cleared when S0_IR is cleared to 0x00.

IMR (Interrupt Mask Register) [R/W] [0x0016] [0x00]

The Interrupt Mask Register is used to mask interrupts. Each interrupt mask bit corresponds to a bit in the Interrupt Register (IR). If an interrupt mask bit is set, an interrupt will be issued whenever the corresponding bit in the IR is set. If any bit in the IMR is set as '0', an interrupt will not occur though the bit in the IR is set.

7	6	5	4	3	2	1	0
IM_IR7	IM_IR6	IM_IR5	Reserved	IM_IR3	IM_IR2	IM_IR1	IM_IR0

Bit	Symbol	Description
7	IM_IR7	**IP Conflict Enable**
6	IM_IR6	**Destination unreachable Enable**
5	IM_IR5	**PPPoE Close Enable**
4	Reserved	**It should be set as '0'**
3	IM_IR3	**Occurrence of Socket 3 Socket Interrupt Enable**
2	IM_IR2	**Occurrence of Socket 2 Socket Interrupt Enable**
1	IM_IR1	**Occurrence of Socket 1 Socket Interrupt Enable**
0	IM_IR0	**Occurrence of Socket 0 Socket Interrupt Enable**

RTR (Retry Time-value Register) [R/W] [0x0017 – 0x0018] [0x07D0]

This register sets the period of timeout. Value 1 means 100us. The initial value is 2000(0x07D0). That will be set as 200ms.

Ex) For 400ms configuration, set as 4000(0x0FA0)

0x0017	0x0018
0x0F	0xA0

Re-transmission will occur if there is no response from the remote peer to the commands of CONNECT, DISCON, CLOSE, SEND, SEND_MAC and SEND_KEEP, or the response is delayed.

RCR (Retry Count Register) [R/W] [0x0019] [0x08]

This register sets the number of re-transmission. If retransmission occurs more than the number recorded in RCR, Timeout Interrupt (TIMEOUT bit of Socket *n* Interrupt Register (Sn_IR) is set as '1') will occur.

RMSR(RX Memory Size Register) [R/W] [0x001A] [0x55]

This register assigns total 8K RX Memory to each socket.

7	6	5	4	3	2	1	0
Socket 3		Socket 2		Socket 1		Socket 0	
S1	S0	S1	S0	S1	S0	S1	S0

The memory size according to the configuration of S1, S0, is as below.

S1	S0	Memory size
0	0	1KB
0	1	2KB
1	0	4KB
1	1	8KB

According to the value of S1 and S0, the memory is assigned to the sockets from socket 0 within the range of 8KB. If there is not enough memory to be assigned, the socket should not be used. The initial value is 0x55 and the 2K memory is assigned to each 4 sockets respectively.

Ex) When setting as 0xAA, the 4KB memory should be assigned to each socket.

However, the total memory size is 8KB. The memory is normally assigned to the socket 0 and 1, but not to the socket 2 and 3. Therefore, socket 2 and 3 can not be absolutely used.

Socket 3	Socket 2	Socket 1	Socket 0
0KB	0KB	4KB	4KB

TMSR(TX Memory Size Register) [R/W] [0x001B] [0x55]

This register is used in assigning total 8K TX Memory to sockets. Configuration can be done in the same way of RX Memory Size Register (RMSR). The initial value is 0x55 and it is to assign 2K memory to 4 sockets respectively.

PATR (Authentication Type in PPPoE mode) [R] [0x001C-0x001D] [0x0000]

This register notifies authentication method that has been agreed at the connection with PPPoE Server. W5100 supports two types of Authentication method - PAP and CHAP.

Value	Authentication Type
0xC023	PAP
0xC223	CHAP

PTIMER (PPP Link Control Protocol Request Timer Register) [R/W] [0x0028] [0x28]

This register indicates the duration for sending LCP Echo Request. Value 1 is about 25ms.

Ex) in case that PTIMER is 200,

200 * 25(ms) = 5000(ms) = 5 seconds

PMAGIC (PPP Link Control Protocol Magic number Register) [R/W] [0x0029] [0x00]

This register is used in Magic number option during LCP negotiation. Refer to the application note, *"How to connect ADSL"*.

UIPR (Unreachable IP Address Register) [R] [0x002A – 0x002D] [0x00]

In case of data transmission using UDP (refer to "5.2.2. UDP"), if transmitting to non-existing IP address, ICMP (Destination Unreachable) packet will be received. In this case, that IP address and port number will be saved in the Unreachable IP Address Register(UIPR) and Unreachable Port Register(UPORT) respectively.

Ex) in case of "192.168.0.11",

0x002A	0x002B	0x002C	0x002D
192 (0xC0)	168 (0xA8)	0 (0x00)	11 (0x0B)

UPORT (Unreachable Port Register) [R] [0x002E – 0x002F] [0x0000]

Refer to Unreachable IP Address Register (UIPR)

Ex) In case of 5000(0x1388),

0x002E	0x002F

0x13	0x88

4.2 Socket Registers

S*n*[1]_MR (Socket *n* Mode Register) [R/W] [0x0400, 0x0500, 0x0600, 0x0700] [0x00][2]

This register sets up socket option or protocol type for each socket.

7	6	5	4	3	2	1	0
MULTI		ND / MC		P3	P2	P1	P0

Bit	Symbol	Description
7	MULTI	**Multicasting** 0 : disable Multicasting 1 : enable Multicasting It is applied only in case of UDP. For using multicasting, write multicast group address to Socket *n* Destination IP and multicast group port number to Socket *n* Destination Port Register, before OPEN command.
6	Reserved	Reserved
5	ND/MC	**Use No Delayed ACK** 0 : Disable No Delayed ACK option 1 : Enable No Delayed ACK option, It is applied only in case of TCP. If this bit is set as '1', ACK packet is transmitted whenever receiving data packet from the peer. If this bit is cleared to '0', ACK packet is transmitted according to internal Timeout mechanism. **Multicast** 0 : using IGMP version 2 1 : using IGMP version 1 It is applied only in case of MULTI bit is '1'
4	Reserved	Reserved
3 2	P3 P2	**Protocol** Sets up corresponding socket as TCP, UDP, or IP RAW mode

P3	P2	P1	P0	Meaning
0	0	0	0	Closed
0	0	0	1	TCP

[1] *n* is socket number (0, 1, 2, 3).

[2] [Read/Write] [address of socket 0, address of socket 1, address of socket 2, address of socket 3] [Reset value]

1	P1	0	0	1	0	UDP
		0	0	1	1	IPRAW
0	P0					

*** In case of socket 0, MACRAW and PPPoE mode exist.**

P3	P2	P1	P0	Meaning
0	1	0	0	MACRAW
0	1	0	1	PPPoE

S*n*_CR (Socket *n* Command Register) [R/W] [0x0401, 0x0501, 0x0601, 0x0701] [0x00]

This register is utilized for socket *n* initialization, close, connection establishment, termination, data transmission and command receipt. After performing the commands, the register value will be automatically cleared to 0x00.

Value	Symbol	Description
0x01	OPEN	It is used to initialize the socket. According to the value of Socket *n* Mode Register (S*n*_MR), Socket *n* Status Register(S*n*_SR) value is changed to SOCK_INIT, SOCK_UDP, SOCK_IPRAW, or SOCK_MACRAW. For more detail, refer to 5. Functional Description.
0x02	LISTEN	It is only used in TCP mode. It changes the value of Socket *n* Status Register (Sn_SR) to SOCK_LISTEN in order to wait for a connection request from any remote peer (TCP Client). For more detail, refer to 5.2.1.1 SERVER mode.
0x04	CONNECT	It is only used in TCP mode. It sends a connection request to remote peer(TCP SERVER). If the connection is failed, Timeout interrupt will occur. For more detail, refer to 5.2.1.2 CLIENT mode.
0x08	DISCON	It is only used in TCP mode. It sends a connection termination request. If connection termination is failed, Timeout interrupt will occur. For more detail, refer to 5.2.1.1 SERVER mode. ** In case of using CLOSE command instead of DISCON, only the value of Socket n Status Register(Sn_SR) is changed to SOCK_CLOSED without the connection termination process.*
0x10	CLOSE	It is used to close the socket. It changes the value of Socket *n* Status Register(S*n*_SR) to SOCK_CLOSED.

0x20	SEND	It transmits the data as much as the increased size of Socket *n* TX Write Pointer. For more detail, refer to Socket *n* TX Free Size Register (S*n*_TX_FSR), Socket *n* TX Write Pointer Register(S*n*_TX_WR), and Socket *n* TX Read Pointer Register(S*n*_TX_RR) or 5.2.1.1. SERVER mode.
0x21	SEND_MAC	It is used in UDP mode. The basic operation is same as SEND. Normally SEND operation needs Destination Hardware Address that is received in ARP(Address Resolution Protocol) process. SEND_MAC uses Socket *n* Destination Hardware Address(S*n*_DHAR) that is written by users without ARP process.
0x22	SEND_KEEP	It is only used in TCP mode. It checks the connection status by sending 1byte data. If the connection is already terminated or peer has no response, Timeout interrupt will occur.
0x40	RECV	Receiving is processed with the value of Socket *n* RX Read Pointer Register(S*n*_RX_RD). For more detail, refer to 5.2.1.1 SERVER mode Receiving Process with Socket *n* RX Received Size Register (S*n*_RX_RSR), Socket *n* RX Write Pointer Register(S*n*_RX_WR), and Socket *n* RX Read Pointer Register(S*n*_RX_RD)

S*n*_IR (Socket *n* Interrupt Register) [R] [0x0402, 0x0502, 0x0602, 0x0702] [0x00]

This register is used for notifying connection establishment and termination, receiving data and Timeout. The Socket *n* Interrupt Register must be cleared by writing '1'.

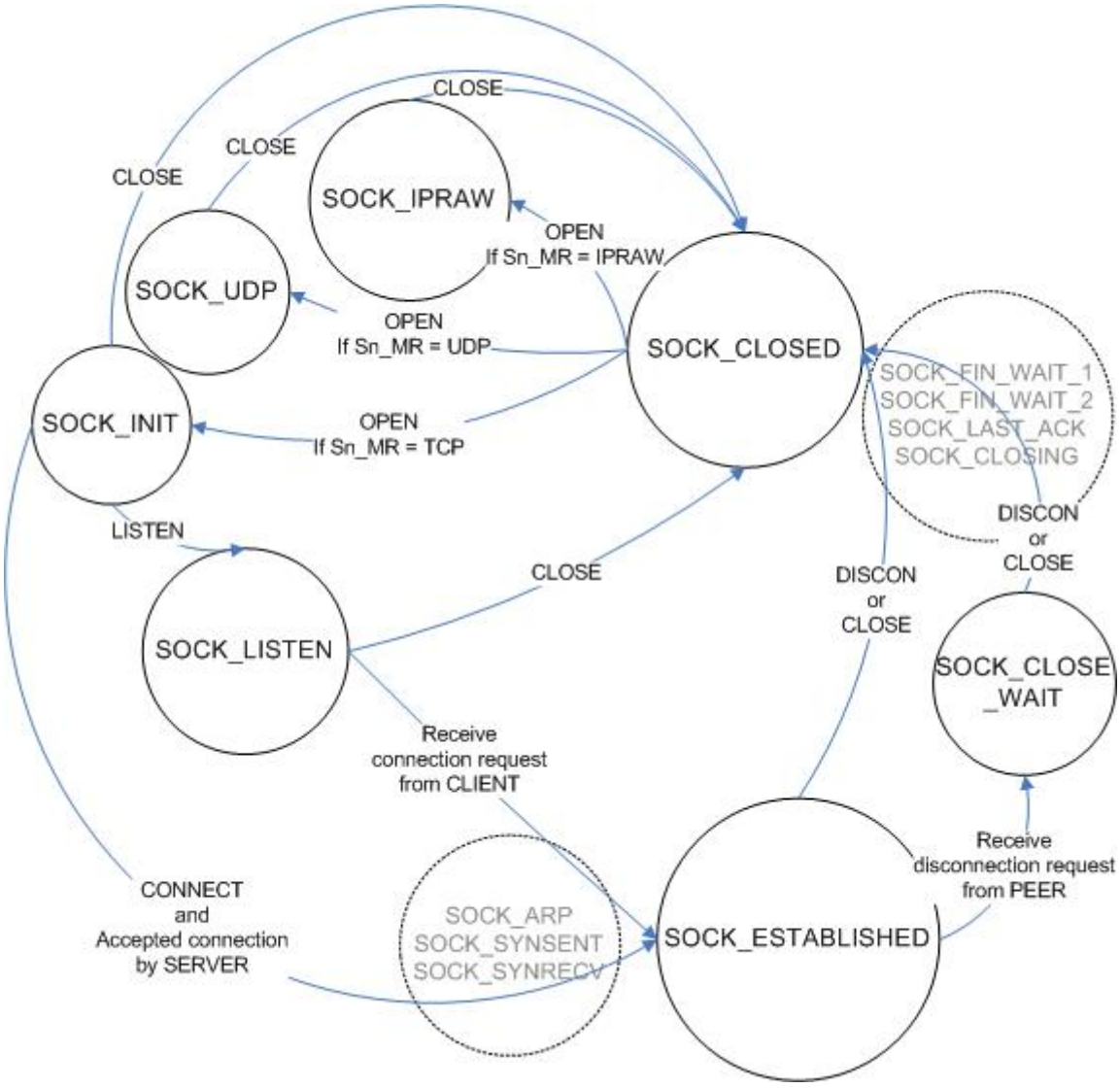
7	6	5	4	3	2	1	0
Reserved	Reserved	Reserved	SEND_OK	TIMEOUT	RECV	DISCON	CON

Bit	Symbol	Description
7	Reserved	Reserved
6	Reserved	Reserved
5	Reserved	Reserved
4	SEND_OK	It is set as '1' if send operation is completed.
3	TIMEOUT	It is set as '1' if Timeout occurs during connection establishment or termination and data transmission.
2	RECV	It is set as '1' if data is received.

1	DISCON	It is set as ‘1’ if connection termination is requested or finished.
0	CON	It is set as ‘1’ if connection is established.

S*n*_SR (Socket *n* Status Register) [R] [0x0403, 0x0503, 0x0603, 0x0703] [0x00]

This register has the status value of socket *n*. The main status is shown in the below diagram.



Value	Symbol	Description
0x00	SOCK_CLOSED	It is shown in case that CLOSE commands are given to S*n*_CR, and Timeout interrupt is asserted or connection is terminated. In this SOCK_CLOSED status, no operation occurs and all resources for the connection is released.
0x13	SOCK_INIT	It is shown in case that S*n*_MR is set as TCP and OPEN

		commands are given to S*n*_CR. This is the initial step for TCP connection establishment of a socket. In this SOCK_INIT status, the command type (LISTEN or CONNECT) of Sn_CR will decide the operation type – TCP server mode or Client mode.
0x14	SOCK_LISTEN	It is shown in case that LISTEN commands are given to S*n*_CR at the SOCK_INIT status. The related socket will operate as TCP Server mode, and become ESTBLISHED status if connection request is normally received.
0x17	SOCK_ESTABLISHED	It is shown in case that connection is established. In this status, TCP data is transmitted and received.
0x1C	SOCK_CLOSE_WAIT	It is shown in case that connection termination request is received from peer host. At this status, the Acknowledge message has been received from the peer, but not disconnected. The connection can be closed by receiving the DICON or CLOSE commands.
0x22	SOCK_UDP	It is shown in case that OPEN commands are given to S*n*_CR when S*n*_MR is set as UDP. As this status does not need the connection process with peer, the data can be directly transmitted and received.
0x32	SOCK_IPRAW	It is shown in case that OPEN commands are given to S*n*_CR when S*n*_MR is set as IPRAW. At the IPRAW status, the following protocols of IP Header are not processed. Refer to “IP RAW” for more information.
0x42	SOCK_MACRAW	It is shown in case that OPEN commands are given to S0_CR when S0_MR is set as MACRAW. At the MAC RAW status, there is no protocol process for a packet. For more information, refer to “MAC RAW”.
0x5F	SOCK_PPPOE	It is shown in case that OPEN commands are given to S0_CR when S0_MR is set as PPPoE.

Below is shown during changing the status.

Value	Symbol	Description
0x15	SOCK_SYNSENT	It is shown in case that CONNECT commands are given to Socket *n* Command Register(S*n*_CR) at the SOCK_INIT status. It is automatically changed to SOCK_ESTABLISH when the connection is established.

0x16	SOCK_SYNRECV	It is shown in case that connection request is received from remote peer(CLIENT). It normally responds to the requests and changes to SOCK_ESTABLISH.
0x18	SOCK_FIN_WAIT	It is shown in the process of connection termination. If the termination is normally processed or Timeout interrupt is asserted, it will be automatically changed to SOCK_CLOSED.
0x1A	SOCK_CLOSING	
0X1B	SOCK_TIME_WAIT	
0X1D	SOCK_LAST_ACK	
0x11 0x21 0x31	SOCK_ARP	It is shown when ARP Request is sent in order to acquire hardware address of remote peer when it sends connection request in TCP mode or sends data in UDP mode. If ARP Reply is received, it changes to the status, SOCK_SYNSENT, SOCK_UDP or SOCK_ICMP, for the next operation.

S*n*_PORT (Socket *n* Source Port Register) [R/W] [0x0404-0x0405, 0x0504-0x0505, 0x0604-0x0605, 0x0704-0x0705] [0x00]

This register sets the Source Port number for each Socket when using TCP or UDP mode, and the set-up needs to be made before executing the OPEN Command.

Ex) In case of Socket 0 Port = 5000(0x1388), configure as below,

0x0404	0x0405
0x13	0x88

S*n*_DHAR (Socket *n* Destination Hardware Address Register) [R/W] [0x0406-0x040B, 0x0506-0x050B, 0x0606-0x060B, 0x0706-0x070B] [0x00]

This register sets the Destination Hardware address of each Socket.

Ex) In case of Socket 0 Destination Hardware address = 08.DC.00.01.02.10, configuration is as below,

0x0406	0x0407	0x0408	0x0409	0x040A	0x040B
0x08	0xDC	0x00	0x01	0x02	0x0A

S*n*_DIPR (Socket *n* Destination IP Address Register) [R/W] [0x040C-0x040F, 0x050C-0x050F, 0x060C-0x060F, 0x070C-0x070F] [0x00]

This register sets the Destination IP Address of each Socket to be used in setting the TCP connection. In active mode, IP address needs to be set before executing the Connect command. In passive mode, W5100 sets up the connection and then is internally updated

with peer IP.

Ex) In case of Socket 0 Destination IP address = 192.168.0.11, configure as below.

0x040C	0x040D	0x040E	0x040F
192 (0xC0)	168 (0xA8)	0 (0x00)	11 (0x0B)

S*n*_DPORT (Socket *n* Destination Port Register) [R/W] [0x0410-0x0411, 0x0510-0x0511, 0x0610-0x0611, 0x0710-0x0711] [0x00]

This register sets the Destination Port number of each socket to be used in setting the TCP connection. In active mode, port number needs to be set before executing the Connect command. In passive mode, W5100 sets up the connection and then is internally updated with peer port number.

Ex) In case of Socket 0 Destination Port = 5000(0x1388), configure as below,

0x0410	0x0411
0x13	0x88

S*n*_MSS (Socket *n* Maximum Segment Size Register) [R/W] [0x0412-0x0413, 0x0512-0x0513, 0x0612-0x0613, 0x0712-0x0713] [0xFFFF]

This register is used for MSS (Maximum Segment Size) of TCP, and the register displays MSS set by the other party when TCP is activated in Passive Mode.

Ex) In case of Socket 0 MSS = 1460(0x05B4), configure as below,

0x0412	0x0413
0x05	0xB4

S*n*_PROTO (Socket *n* IP Protocol Register) [R/W] [0x0414, 0x0514, 0x0614, 0x0714] [0x00]

This IP Protocol Register is used to set up the Protocol Field of IP Header at the IP Layer RAW Mode. There are several protocol numbers defined in advance by registering to IANA. For the overall list of upper level protocol identification number that IP is using, refer to online documents of IANA (http://www.iana.org/assignments/protocol-numbers).

Ex) Internet Control Message Protocol (ICMP) = 0x01, Internet Group Management Protocol = 0x02

S*n*_TOS (Socket *n* IP Type Of Service Register) [R/W] [0x0415,0x0515,0x0615,0x0715]

[0x00]

This register sets up at the TOS Field of IP Header.

S*n*_TTL (Socket *n* IP Time To Live Register) [R/W] [0x0416,0x0516,0x0616,0x0716] [0x80]

This register sets up at the TTL Field of IP Header.

S*n*_TX_FSR (Socket *n* TX Free Size Register) [R] [0x0420-0x0421, 0x0520-0x0521, 0x0620-0x0621, 0x0720-0x0721] [0x0800]

This register notifies the information of data size that user can transmit. For data transmission, user should check this value first and control the size of transmitting data. *When checking this register, user should read upper byte(0x0420,0x0520,0x0620,0x0720) first and lower byte(0x0421,0x0521,0x0621,0x0721) later to get the correct value.*

Ex) In case of 2048(0x0800) in S0_TX_FSR,

0x0420	0x0421
0x08	0x00

Total size can be decided according to the value of TX Memory Size Register. In the process of transmission, it will be reduced by the size of transmitting data, and automatically increased after transmission finished.

S*n*_TX_RR (Socket *n* TX Read Pointer Register) [R] [0x0422-0x0423, 0x0522-0x0523, 0x0622-0x0623, 0x0722-0x0723] [0x0000]

This register shows the address that transmission is finished at the TX Memory. With the SEND command of Socket *n* Command Register, it transmits data from current S*n*_TX_RR to S*n*_TX_WR and automatically changes after transmission is finished. Therefore, after transmission is finished, S*n*_TX_RR and S*n*_TX_WR will have same value. When reading this register, user should read upper byte (0x0422, 0x0522, 0x0622, 0x0722) first and lower byte (0x0423, 0x0523, 0x0623, 0x0723) later to get the correct value.

S*n*_TX_WR (Socket *n* TX Write Pointer Register) [R/W] [0x0424-0x0425, 0x0524-0x0525, 0x0624-0x0625, 0x0724-0x0725] [0x0000]

This register offers the location information to write the transmission data. When reading this register, user should read upper byte (0x0424, 0x0524, 0x0624, 0x0724) first and lower byte (0x0425, 0x0525, 0x0625, 0x0725) later to get the correct value.

Ex) In case of 2048(0x0800) in S0_TX_WR,

0x0424	0x0425
0x08	0x00

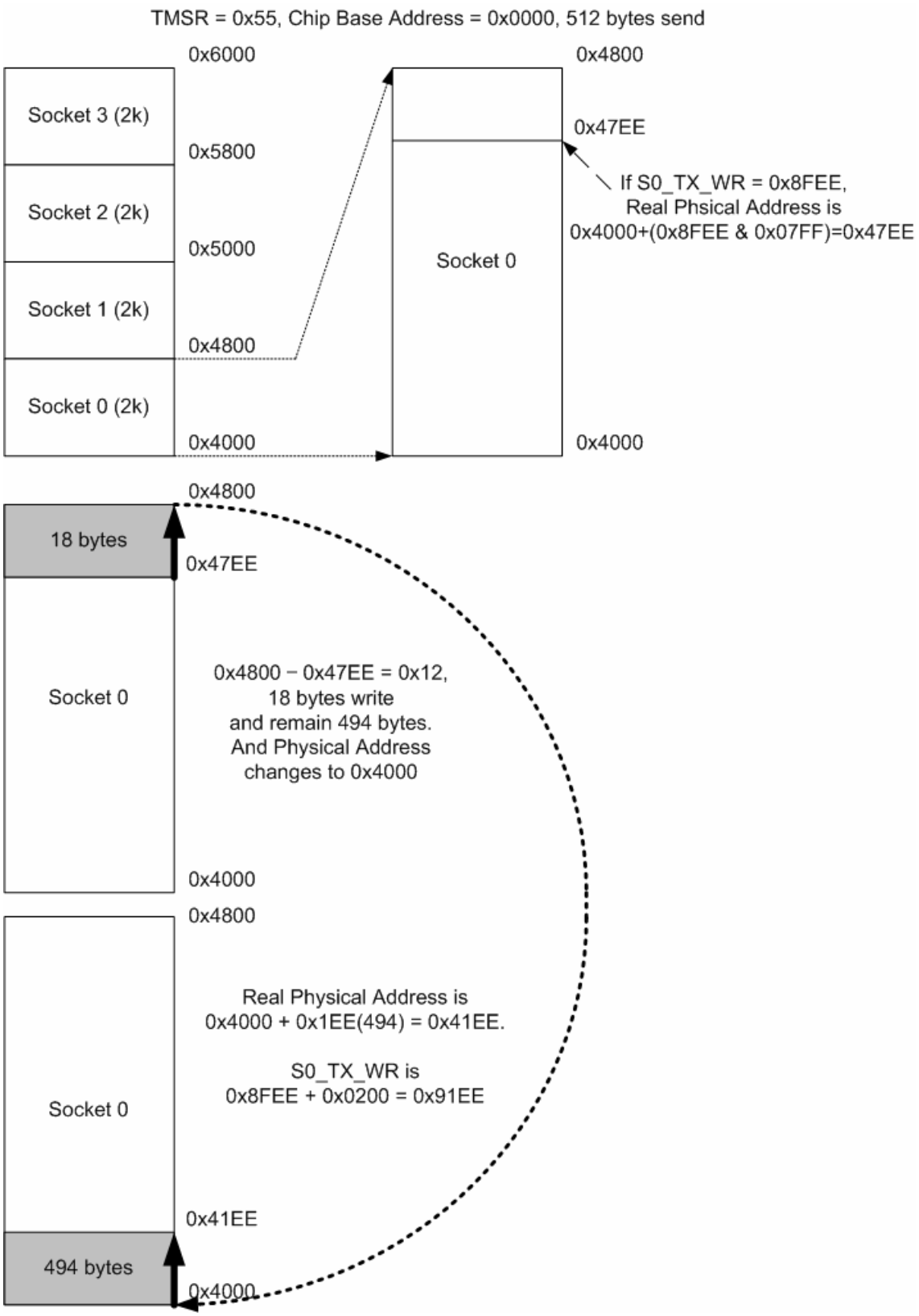
But this value itself is not the physical address to write. So, the physical address should be calculated as follow.

1. Socket *n* TX Base Address (hereafter we'll call *gSn_TX_BASE)* and Socket *n* TX Mask Address (hereafter we'll call *gSn_TX_MASK)* are calculated on TMSR value. *Refer to the psedo code of the Initialization if the detail is needed.*
2. The bitwise-AND operation of two values, Sn_TX_WR and *gSn_TX_MASK* give result the offset address(hereafter we'll call *get_offset*) in TX memory range of the socket.
3. Two values *get_offset* and *gSn_TX_BASE* are added together to give result the physical address(hereafter, we'll call *get_start_address*).

Now, write the transmission data to *get_start_address* as large as you want. (* There's a case that it exceeds the TX memory upper-bound of the socket while writing. In this case, write the transmission data to the upper-bound, and change the physical address to the *gSn_TX_BASE*. Next, write the rest of the transmission data.)

After that, be sure to increase the Sn_TX_WR value as much as the data size that indicates the size of writing data. Finally, give SEND command to Sn_CR(Socket *n* Command Register).

Refer to the psedo code of the transmission part on TCP Server mode if the detail is needed.



Calculate physical address

S*n*_RX_RSR (RX Received Size Register) [R] [0x0426-0x0427, 0x0526-0x0527, 0x0626-0x0627, 0x0726-0x0727] [0x0000]

This register notifies the data size received in RX Memory. As this value is internally calculated with the values of S*n*_RX_RD and S*n*_RX_WR, it is automatically changed by RECV command of Socket *n* Command Register(S*n*_CR) and receiving data for remote peer. *When reading this register, user should read upper byte(0x0426,0x0526,0x0626,0x0726) first and lower byte(0x0427,0x0527,0x0627,0x0727) later to get the correct value.*

Ex) In case of 2048(0x0800) in S0_RX_RSR,

0x0426	0x0427
0x08	0x00

The total size of this value can be decided according to the value of RX Memory Size Register.

S*n*_RX_RD (Socket *n* RX Read Pointer Register) [R/W] [0x0428-0x0429, 0x0528-0x0529, 0x0628-0x0629, 0x0728-0x0729] [0x0000]

This register offers the location information to read the receiving data. When reading this register, user should read upper byte (0x0428, 0x0528, 0x0628, 0x0728) first and lower byte (0x0429, 0x0529, 0x0629, 0x0729) later to get the correct value.

Ex) In case of 2048(0x0800) in S0_RX_RD,

0x0428	0x0429
0x08	0x00

But this value itself is not the physical address to read. So, the physical address should be calculated as follow.

1. Socket *n* RX Base Address (hereafter we'll call *gSn_RX_BASE)* and Socket *n* RX Mask Address (hereafter we'll call *gSn_RX_MASK)* are calculated on RMSR value. *Refer to the pseudo code of the 5.1 Initialization if the detail is needed.*
2. The bitwise-AND operation of two values, Sn_RX_RD and *gSn_RX_MASK* give result the offset address(hereafter we'll call *get_offset)*, in RX memory range of the socket.
3. Two values *get_offset* and *gSn_RX_BASE* are added together to give result the physical address(hereafter, we'll call *get_start_address).*

Now, read the receiving data from *get_start_address* as large as you want. (* There's a case that it exceeds the RX memory upper-bound of the socket while reading. In this case, read the receiving data to the upper-bound, and change the physical address to the *gSn_RX_BASE*. Next, read the rest of the receiving data.)

After that, be sure to increase the Sn_RX_RD value as large as the data size that indicates the size of reading data. (* Must not increase more than the size of received data. So must check Sn_RX_RSR before receiving process.) Finally, give RECV command to Sn_CR(Socket *n*

Command Register).

Refer to the pseudo code of the receiving part on TCP Server mode if the detail is needed.

5. Functional Descriptions

By setting some register and memory operation, W5100 provides internet connectivity. This chapter describes how it can be operated.

5.1 Initialization

- Basic Setting

For the W5100 operation, select and utilize appropriate registers shown below.

1. Mode Register (MR)
2. Interrupt Mask Register (IMR)
3. Retry Time-value Register (RTR)
4. Retry Count Register (RCR)

For more information of above registers, refer to the “Register Descriptions”.

- Setting network information

Below register is for basic network configuration information to be configured according to the network environment.

1. Gateway Address Register (GAR)
2. Source Hardware Address Register (SHAR)
3. Subnet Mask Register (SUBR)
4. Source IP Address Register (SIPR)

The Source Hardware Address Register (SHAR) is the H/W address to be used in MAC layer, and can be used with the address that manufacturer has been assigned. The MAC address can be assigned from IEEE. For more detail, refer to IEEE homepage.

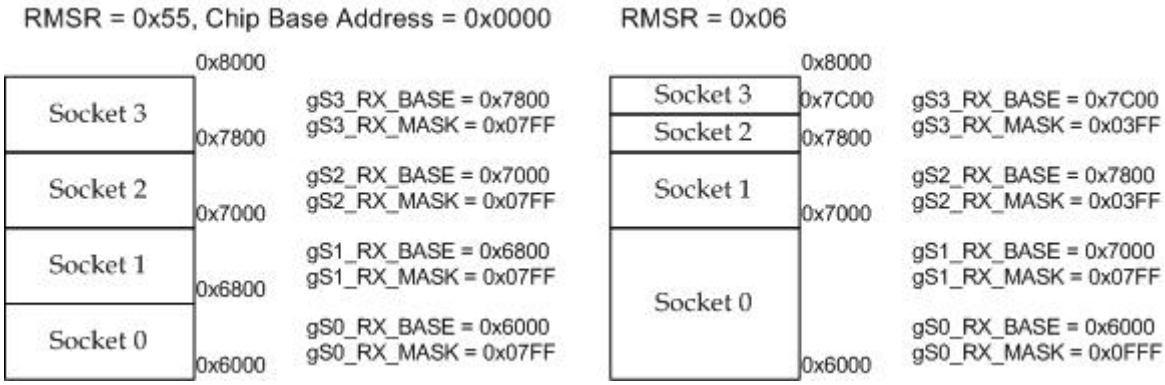
- Set socket memory information

This stage sets the socket tx/rx memory information. The base address and mask address of each socket are fixed and saved in this stage.

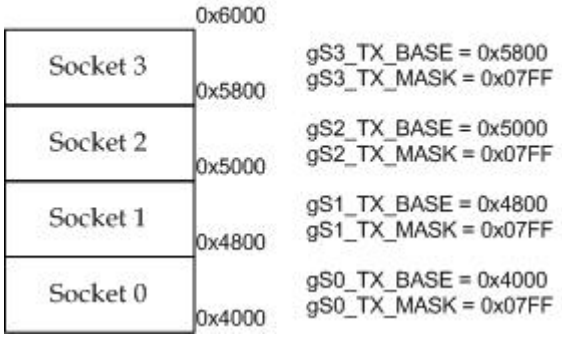
```
In case of, assign 2K rx memory per socket.
{
    RMSR = 0x55; // assign 2K rx memory per socket.
    gS0_RX_BASE = chip_base_address + RX_memory_base_address(0x6000);
    gS0_RX_MASK = 2K - 1 ; // 0x07FF, for getting offset address within assigned socket 0 RX
memory.
    gS1_RX_BASE = gS0_BASE + (gS0_MASK + 1);
    gS1_RX_MASK = 2K - 1 ;
```

```
    gS2_RX_BASE = gS1_BASE + (gS1_MASK + 1);
    gS2_RX_MASK = 2K - 1 ;
    gS3_RX_BASE = gS2_BASE + (gS2_MASK + 1);
    gS3_RX_MASK = 2K - 1 ;
    TMSR = 0x55; // assign 2K tx memory per socket.
    Same method, set gS0_TX_BASE, gS0_TX_MASK, gS1_TX_BASE, gS1_TX_MASK,
    gS2_TX_BASE, gS2_TX_MASK, gS3_TX_BASE and gS3_TX_MASK.
}
```

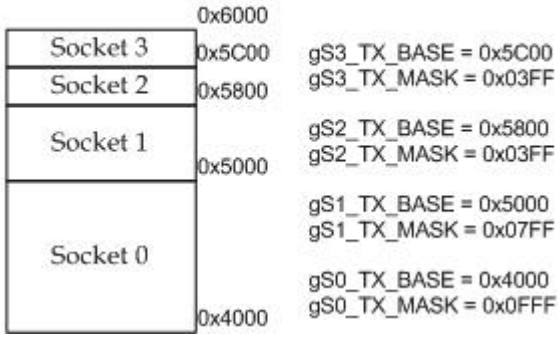
```
In case of, assign 4K,2K,1K,1K.
{
    RMSR = 0x06; // assign 4K,2K,1K,1K rx memory per socket.
    gS0_RX_BASE = chip_base_address + RX_memory_base_address(0x6000);
    gS0_RX_MASK = 4K - 1 ; // 0x0FFF, for getting offset address within assigned socket 0 RX
memory.
    gS1_RX_BASE = gS0_BASE + (gS0_MASK + 1);
    gS1_RX_MASK = 2K - 1 ; // 0x07FF
    gS2_RX_BASE = gS1_BASE + (gS1_MASK + 1);
    gS2_RX_MASK = 1K - 1 ; // 0x03FF
    gS3_RX_BASE = gS2_BASE + (gS2_MASK + 1);
    gS3_RX_MASK = 1K - 1 ; // 0x03FF
    TMSR = 0x06; // assign 4K,2K,1K,1K rx memory per socket.
    Same method, set gS0_TX_BASE, gS0_TX_MASK, gS1_TX_BASE, gS1_TX_MASK,
    gS2_TX_BASE, gS2_TX_MASK, gS3_TX_BASE and gS3_TX_MASK.
}
```



TMSR = 0x55, Chip Base Address = 0x0000



TMSR = 0x06

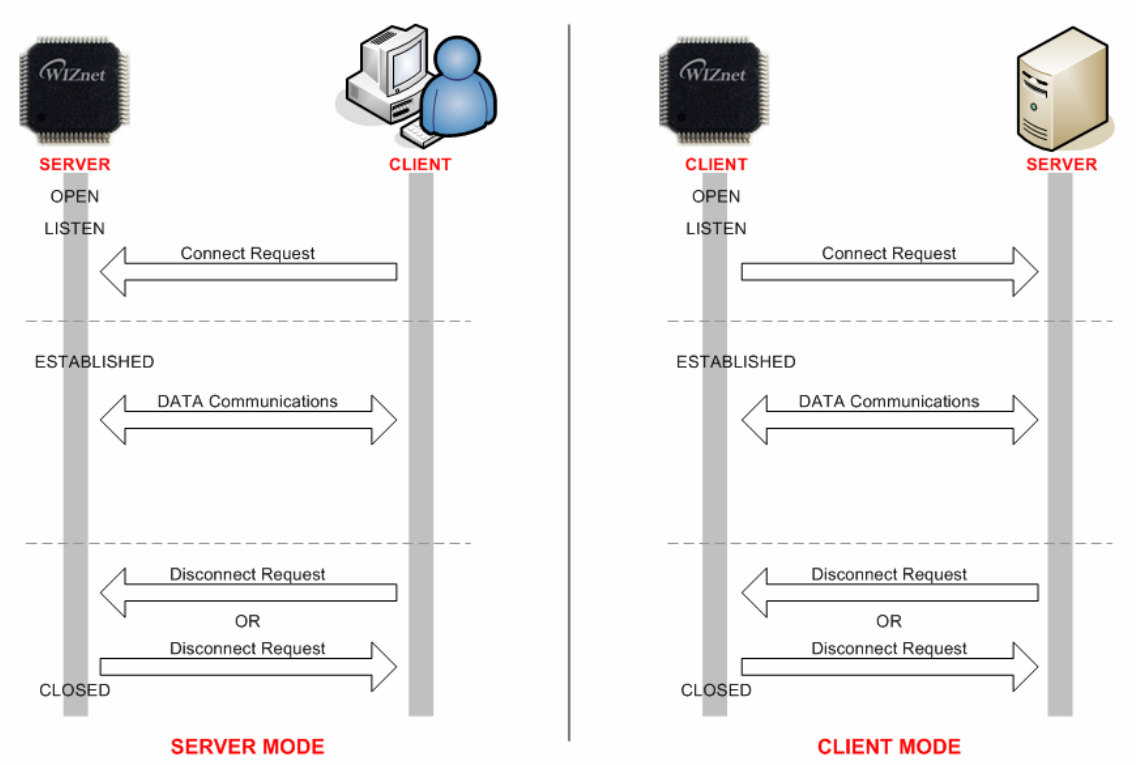


5.2 Data Communications

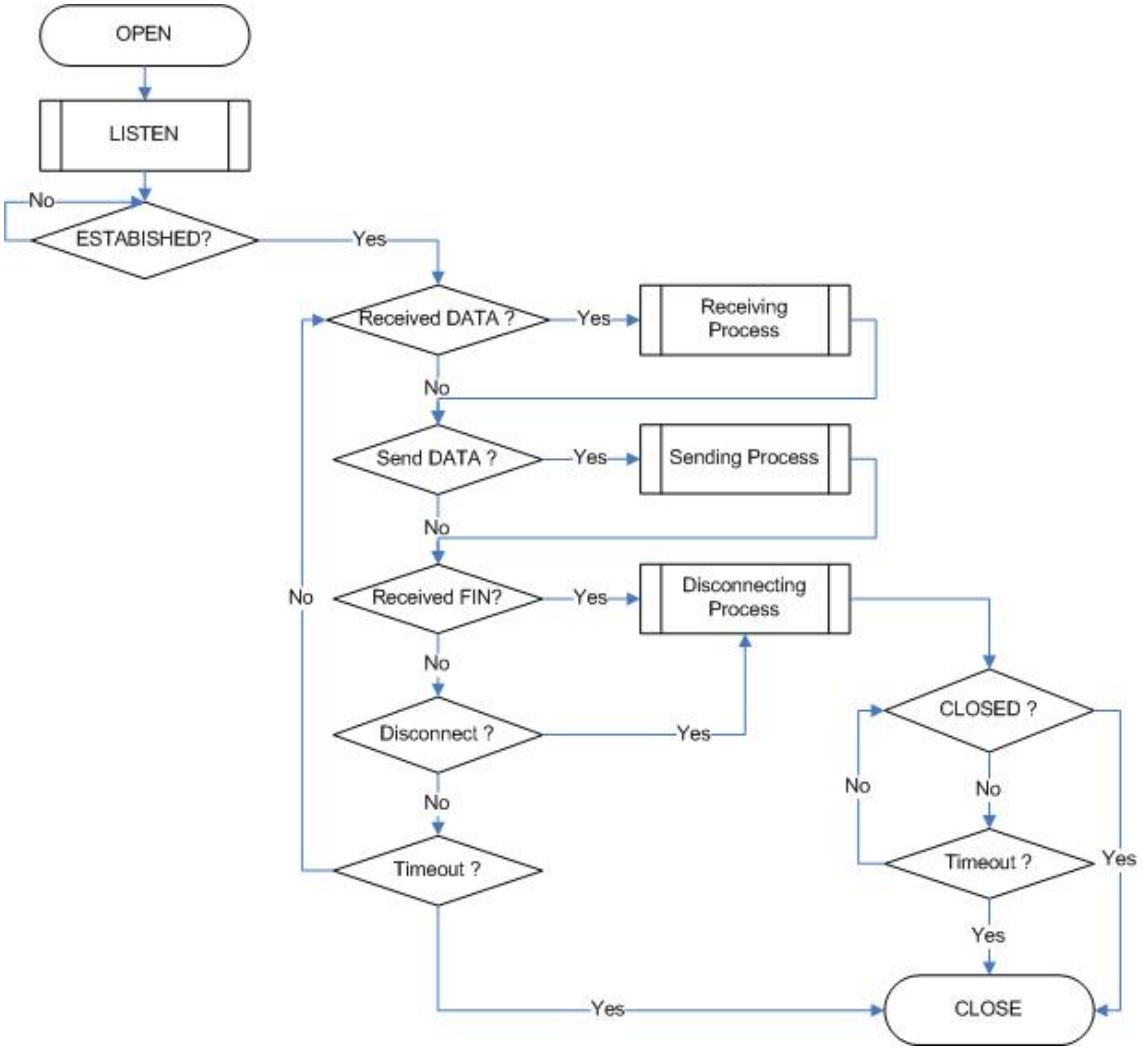
Data communication is available through TCP, UDP, IP-Raw and MAC-Raw . In order to select it, configure protocol field of Socket *n* Mode Register(S*n*_MR) of the communication sockets (W5100 supports total 4 sockets).

5.2.1 TCP

TCP is the connection based communication method that will establish connection in advance and deliver the data through the connection by using IP Address and Port number of the systems. There are two methods to establish the connection. One is SERVER mode(passive open) that is waiting for connection request. The other is CLIENT mode (active open) that sends connection request to a server.



5.2.1.1 SERVER mode



■ Socket Initialization

In order to initialize a socket, set the operation mode and port of the socket, and provide OPEN command to the command register of the socket. Below is the registers related.

Socket n Mode Register (Sn_MR)

Socket n Source Port Register (Sn_PORT)

Socket n Command Register (Sn_CR)

It initializes the socket *n* as TCP,

```
{
START:
    /* sets TCP mode */
    Sn_MR = 0x01;
    /* sets source port number */
    Sn_PORT = source_port;
```

```
    /* sets OPEN command */
    Sn_CR = OPEN;
    if (Sn_SR != SOCK_INIT) Sn_CR = CLOSE; goto START;
}
```

■ LISTEN

Set the LISTEN command to the command register. The related register is below.

Socket n Command Register (Sn_CR)

```
{
    /* listen socket */
    Sn_CR = LISTEN;
    if (Sn_SR != SOCK_LISTEN) Sn_CR = CLOSE; goto START; // check socket status
}
```

■ ESTABLISHED ?

If connection request is received from remote peer (the status of SOCK_SYNRECV), W5100 sends ACK packet and changes to SOCK_ESTABLISHED status. This status can be checked as below.

```
First method :
{
    If (Sn_IR(CON bit) == '1') goto ESTABLISHED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second method :
{
    If (Sn_SR == SOCK_ESTABLISHED) goto ESTABLISHED stage;
}
```

As connection is established, data transmission and receipt can be performed.

■ ESTABLISHED : Received Data ?

Check as below to know if data is received from remote peer or not.

```
First method :
{
    If (Sn_IR(RECV bit) == '1') goto Receiving Process stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second Method :
{
    if (Sn_RX_RSR != 0x0000) goto Receiving Process stage;
}
```

■ ESTABLISHED : Receiving Process

Received data can be processed as below.

```
{
    /* first, get the received size */
    get_size = Sn_RX_RSR;
    /* calculate offset address */
    get_offset = Sn_RX_RD & gSn_RX_MASK;
    /* calculate start address(physical address) */
    get_start_address = gSn_RX_BASE + get_offset;

    /* if overflow socket RX memory */
    if ( (get_offset + get_size) > (gSn_RX_MASK + 1) )
    {
        /* copy upper_size bytes of get_start_address to destination_addr */
        upper_size = (gSn_RX_MASK + 1) - get_offset;
        memcpy(get_start_address, destination_addr, upper_size);
        /* update destination_addr*/
        destination_addr += upper_size;
        /* copy left_size bytes of gSn_RX_BASE to destination_addr */
        left_size = get_size - upper_size;
        memcpy(gSn_RX_BASE, destination_addr, left_size);
    }
    else
```

```
    {
        /* copy get_size bytes of get_start_address to destination_addr */
        memcpy(get_start_address, destination_addr, get_size);
    }
    /* increase Sn_RX_RD as length of get_size */
    Sn_RX_RD += get_size;
    /* set RECV command */
    Sn_CR = RECV;
}
```

■ ESTABLISHED : Send DATA ? / Sending Process

The sending procedure is as below.

```
{
    /* first, get the free TX memory size */
FREESIZE:
    get_free_size = Sn_TX_FSR;
    if (get_free_size < send_size) goto FREESIZE;

    /* calculate offset address */
    get_offset = Sn_TX_WR & gSn_TX_MASK;
    /* calculate start address(physical address) */
    get_start_address = gSn_TX_BASE + get_offset;

    /* if overflow socket TX memory */
    if ( (get_offset + send_size) > (gSn_TX_MASK + 1) )
    {
        /* copy upper_size bytes of source_addr to get_start_address */
        upper_size = (gSn_TX_MASK + 1) - get_offset;
        memcpy(source_addr, get_start_address, upper_size);
        /* update source_addr*/
        source_addr += upper_size;
        /* copy left_size bytes of source_addr to gSn_TX_BASE */
        left_size = send_size - upper_size;
        memcpy(source_addr, gSn_TX_BASE, left_size);
    }
    else
```

```
    {
        /* copy send_size bytes of source_addr to get_start_address */
        memcpy(source_addr, get_start_address, send_size);
    }
    /* increase Sn_TX_WR as length of send_size */
    Sn_TX_WR += send_size;
    /* set SEND command */
    Sn_CR = SEND;
}
```

■ ESTABLISHED : Received FIN?

Waiting for a connection termination request from remote peer.

It can be checked as below if it received connection termination request of remote peer.

```
First method :
{
    If (Sn_IR(DISCON bit) == '1') goto CLOSED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second method :
{
    If (Sn_SR == SOCK_CLOSE_WAIT) goto CLOSED stage;
}
```

■ ESTABLISHED : Disconnect ? / Disconnecting Process

Check if user requests to terminate this connection.

To terminate the connection, proceed as below,

```
{
    /* set DISCON command */
    Sn_CR = DISCON;
}
```

■ ESTABLISHED : CLOSED ?

No connection state at all. It can be checked as below,

```
First method :
{
    If (Sn_IR(DISCON bit) == '1') goto CLOSED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second method :
{
    If (Sn_SR == SOCK_CLOSED) goto CLOSED stage;
}
```

■ ESTABLISHED : Timeout

In case that connection is closed due to the error of remote peer during data receiving or connection closing process, data transmission can not be normally processed. At this time Timeout occurs after some time.

```
First method :
{
    If (Sn_IR(TIMEOUT bit) == '1') goto CLOSED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second method :
{
    If (Sn_SR == SOCK_CLOSED) goto CLOSED stage;
}
```

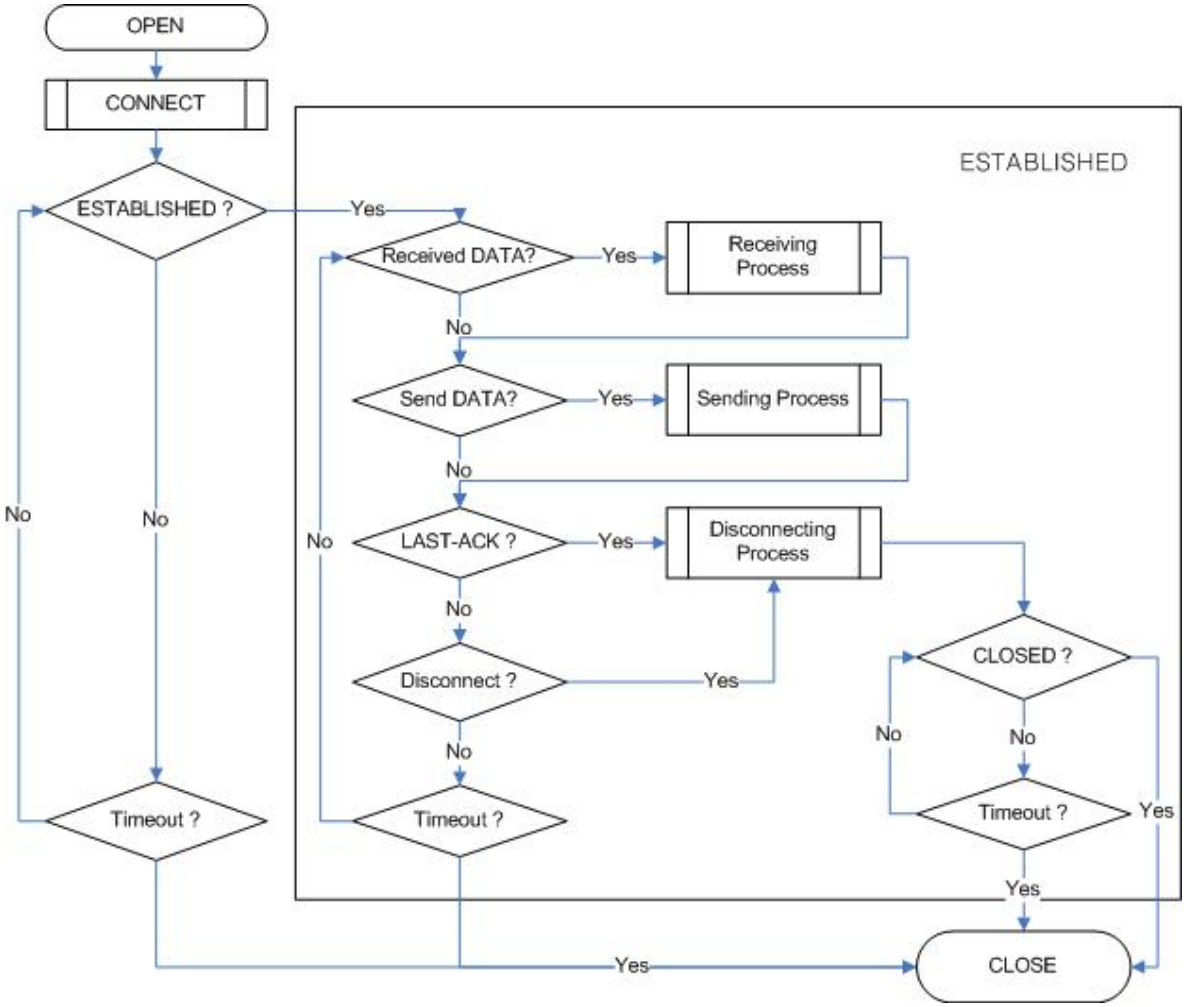
■ Socket Close

This process should be processed in case that connection is closed after data exchange, socket should be closed with Timeout occurrence, or forcible disconnection is necessary due to abnormal operation.

```
{
    /* set CLOSE command */
    Sn_CR = CLOSE;
}
```

5.2.1.2 CLIENT mode

Whole process is shown as below.



■ Socket Initialization

Refer to "5.2.1.1 SERVER mode" (The operation is same as SERVER).

■ CONNECT

Send connection request to remote HOST(SERVER) is as below.

```
{
    /* Write the value of server_ip, server_port to the Socket n Destination IP Address
       Register(Sn_DIPR), Socket n Destination Port Register(Sn_DPORT). */
    Sn_DIPR = server_ip;
    Sn_DPORT = server_port;
    /* set CONNECT command */
```

```
    Sn_CR = CONNECT;
}
```

■ ESTABLISHED ?

The connection is established. It can be checked as below,

```
First method :
{
    If (Sn_IR(CON bit) == '1') goto ESTABLISHED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

```
Second method :
{
    If (Sn_SR == SOCK_ESTABLISHED) goto ESTABLISHED stage;
}
```

■ Timeout

Socket is closed as Timeout occurs as there is not response from remote peer. It can be checked as below.

```
First method :
{
    If (Sn_IR(TIMEOUT bit) == '1') goto CLOSED stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

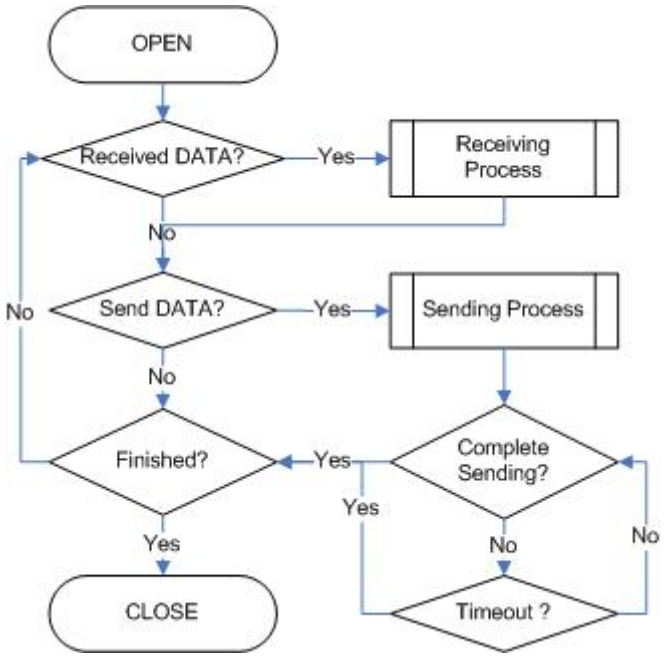
```
Second method :
{
    If (Sn_SR == SOCK_CLOSED) goto CLOSED stage;
}
```

■ ESTABLISHED

Refer to "5.2.1.1. SERVER mode" (The operation is same as SERVER mode)

5.2.2 UDP

UDP provides unreliable and connectionless datagram transmission structure. It processes data without connection establishment. Therefore, UDP message can be lost, overlapped or reversed. As packets can arrive faster, recipient can not process all of them. In this case, user application should guarantee the reliability of data transmission. UDP transmission can be processed as below,



■ Socket Initialization

Initialize the socket *n* as UDP.

```
{
START:
    /* sets UDP mode */
    Sn_MR = 0x02;
    /* sets source port number */
     /* ※ The value of Source Port can be appropriately delivered when remote HOST knows it. */
    Sn_PORT = source_port;
    /* sets OPEN command */
    Sn_CR = OPEN;
    /* Check if the value of Socket n Status Register(Sn_SR) is SOCK_UDP. */
    if (Sn_SR != SOCK_UDP) Sn_CR = CLOSE; goto START;
}
```

■ Received DATA?

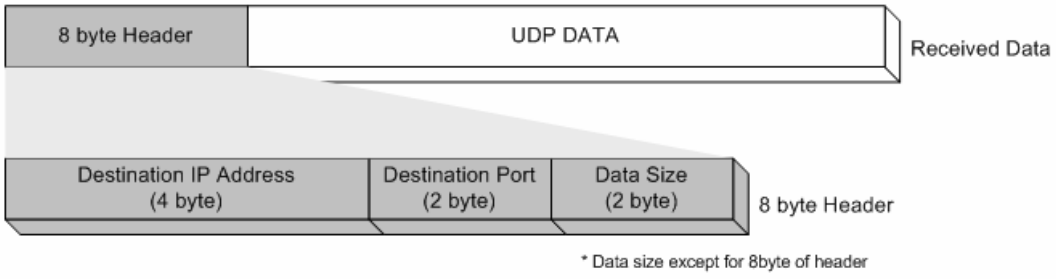
It can be checked as below if data is received from remote peer.

```
First method :
{
    if (Sn_RX_RSR != 0x0000) goto Receiving Process stage;
}
```

```
Second Method :
{
    If (Sn_IR(RECV bit) == '1') goto Receiving Process stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

■ Receiving Process

Received data can be processed as below. In case of UDP, 8byte header is attached to receiving data. The structure of the header is as below.




```
{
    /* first, get the received size */
    get_size = Sn_RX_RSR;
    /* calculate offset address */
    get_offset = Sn_RX_RD & gSn_RX_MASK;
    /* calculate start address(physical address) */
    get_start_address = gSn_RX_BASE + get_offset;

    /* read head information (8 bytes) */
    header_size = 8;
```

```
/* if overflow socket RX memory */
if ( (get_offset + header_size) > (gSn_RX_MASK + 1) )
{
    /* copy upper_size bytes of get_start_address to header_addr */
    upper_size = (gSn_RX_MASK + 1) - get_offset;
    memcpy(get_start_address, header_addr, upper_size);
    /* update header_addr*/
    header_addr += upper_size;
    /* copy left_size bytes of gSn_RX_BASE to header_addr */
    left_size = header_size - upper_size;
    memcpy(gSn_RX_BASE, header_addr, left_size);
    /* update get_offset */
    get_offset = left_size;
}
else
{
    /* copy header_size bytes of get_start_address to header_addr */
    memcpy(get_start_address, header_addr, header_size);
    /* update get_offset */
    get_offset += header_size;
}
/* update get_start_address */
get_start_address = gSn_RX_BASE + get_offset;

/* save remote peer information & received data size */
peer_ip = header[0 to 3];
peer_port = header[4 to 5];
get_size = header[6 to 7];

/* if overflow socket RX memory */
if ( (get_offset + get_size) > (gSn_RX_MASK + 1) )
{
    /* copy upper_size bytes of get_start_address to destination_addr */
    upper_size = (gSn_RX_MASK + 1) - get_offset;
    memcpy(get_start_address, destination_addr, upper_size);
    /* update destination_addr*/
    destination_addr += upper_size;
```

```
        /* copy left_size bytes of gSn_RX_BASE to destination_addr */
        left_size = get_size - upper_size;
        memcpy(gSn_RX_BASE, destination_addr, left_size);
    }
    else
    {
        /* copy get_size bytes of get_start_address to destination_addr */
        memcpy(get_start_address, destination_addr, get_size);
    }
    /* increase Sn_RX_RD as length of get_size+header_size */
    Sn_RX_RD = Sn_RX_RD + get_size + header_size;
    /* set RECV command */
    Sn_CR = RECV;
}
```

■ Send Data? / Sending Process

Data transmission process is as below.

```
{
    /* first, get the free TX memory size */
FREESIZE:
    get_free_size = Sn_TX_FSR;
    if (get_free_size < send_size) goto FREESIZE;

    /* Write the value of remote_ip, remote_port to the Socket n Destination IP Address
       Register(Sn_DIPR), Socket n Destination Port Register(Sn_DPORT). */
    Sn_DIPR = remote_ip;
    Sn_DPORT = remote_port;

    /* calculate offset address */
    get_offset = Sn_TX_WR & gSn_TX_MASK;
    /* calculate start address(physical address) */
    get_start_address = gSn_TX_BASE + get_offset;

    /* if overflow socket TX memory */
    if ( (get_offset + send_size) > (gSn_TX_MASK + 1) )
    {
```

```
        /* copy upper_size bytes of source_addr to get_start_address */
        upper_size = (gSn_TX_MASK + 1) - get_offset;
        memcpy(source_addr, get_start_address, upper_size);
        /* update source_addr*/
        source_addr += upper_size;
        /* copy left_size bytes of source_addr to gSn_TX_BASE */
        left_size = send_size - upper_size;
        memcpy(source_addr, gSn_TX_BASE, left_size);
    }
    else
    {
        /* copy send_size bytes of source_addr to get_start_address */
        memcpy(source_addr, get_start_address, send_size);
    }
    /* increase Sn_TX_WR as length of send_size */
    Sn_TX_WR += send_size;
    /* set SEND command */
    Sn_CR = SEND;
}
```

■ Complete Sending?

The sending completion should be checked after SEND command.

```
{
    If (Sn_CR == 0x00) transmission is completed.
}
```

■ Timeout

Timeout occurs if remote peer does not exist or data transmission is not normally processed. It can be checked as below.

```
{
    If (Sn_IR(TIMEOUT bit) == '1') goto next stage;
    /* In this case, if the interrupt of Socket n is activated, interrupt occurs. Refer to
       Interrupt Register(IR), Interrupt Mask Register (IMR) and Socket n Interrupt Register
       (Sn_IR). */
}
```

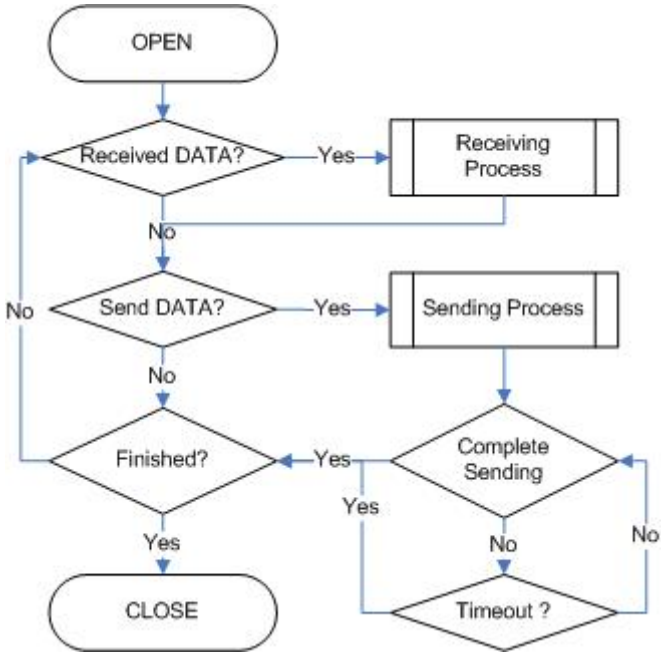
- Finished? / Socket Close

If all the actions are finished, close the socket.

```
{
    /* set CLOSE command */
    Sn_CR = CLOSE;
}
```

5.2.3 IP raw

IP Raw mode can be utilized if transport layer protocol of some ICMP or IGMP that W5100 does not support, needs to be processed.



- Socket Initialization

It initializes the socket as IP raw.

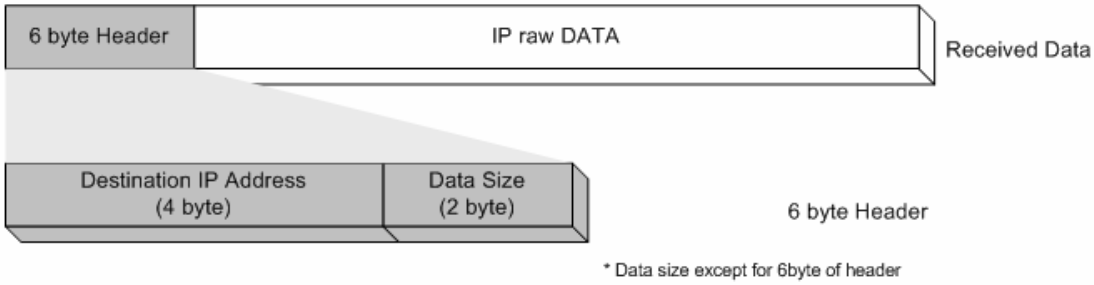
```
{
START:
    /* sets IP raw mode */
    Sn_MR = 0x03;
    /* sets Protocol value */
    /* The value of Protocol is used in Protocol Field of IP Header.
     For the list of protocol identification number of upper classification, refer to on line
     documents of IANA (http://www.iana.org/assignments/protocol-numbers). */
    Sn_PROTO = protocol_value;
    /* sets OPEN command */
    Sn_CR = OPEN;
    /* Check if the value of Socket n Status Register(Sn_SR) is SOCK_IPRAW. */
    if (Sn_SR != SOCK_IPRAW) Sn_CR = CLOSE; goto START;
}
```

- Received DATA?

It is same as UDP. Refer to “5.2.2 UDP”.

- Receiving Process

This is same as UDP. Refer to “5.2.2 UDP” except the header information and header size. In case of IP raw, 6byte header is attached to the data received. The header structure is as below.



- Send DATA? / Sending Process

This is same as UDP. Refer to “5.2.2 UDP” except that remote_port information is not needed.

- Complete Sending
- Timeout
- Finished? / Socket Closed

Next actions are same as UDP. Refer to “5.2.2 UDP”.

5.2.4 MAC raw

MAC Raw mode(only supported in socket 0) can be utilized.

- Socket Initialization

It initializes the socket as MAC raw.

```
{
START:
    /* sets MAC raw mode */
```

```
    Sn_MR = 0x04;
    /* sets OPEN command */
    Sn_CR = OPEN;
    /* Check if the value of Socket n Status Register(Sn_SR) is SOCK_MACRAW. */
    if (Sn_SR != SOCK_MACRAW) Sn_CR = CLOSE; goto START;
}
```

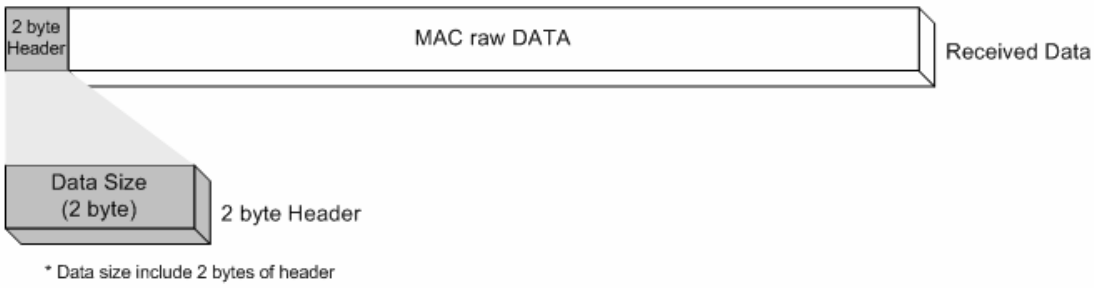
■ Received DATA?

This is same as UDP. Refer to “5.2.2 UDP”.

■ Receiving Process

MAC raw received Ethernet packet having packet size information.

In case of MAC raw, 2byte header is attached to the data received. The header structure is as below.



■ Send DATA? / Sending Process

This is same as UDP. Refer to “5.2.2 UDP” except that remote_port information is not needed.

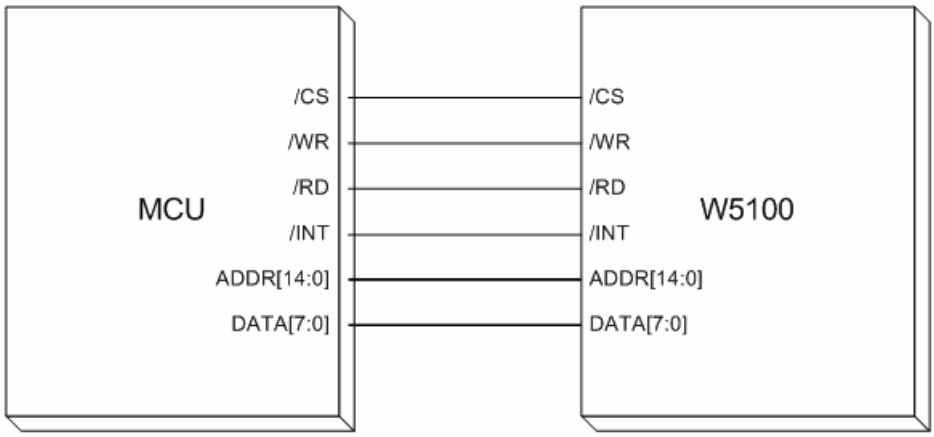
6. Application Information

For the communication with MCU, W5100 provides Direct, Indirect Bus I/F, and SPI I/F modes.

For the communication with Ethernet PHY, MII is used.

6.1 Direct Bus Interface mode

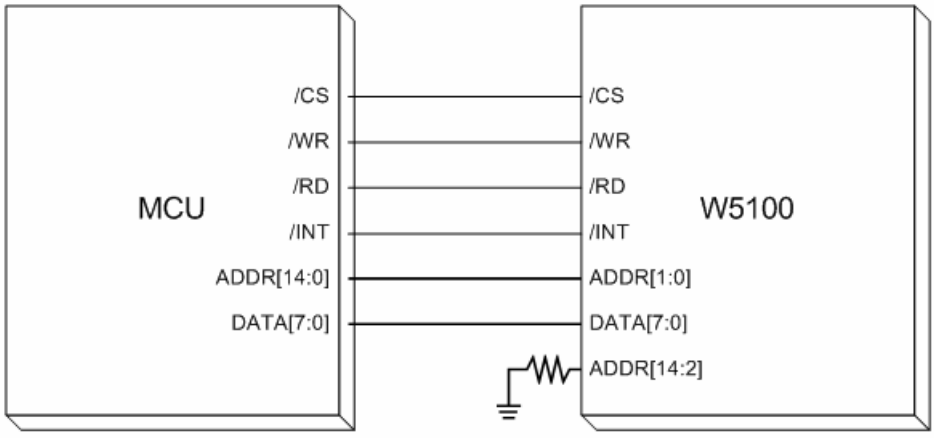
Direct Bus I/F mode uses 15bit address line and 8bit data line, /CS, /RD, /WR, /INT.



6.2 Indirect Bus Interface mode

Indirect Bus I/F mode uses 2bit address line and 8bit data line, /CS, /RD, /WR, /INT.

[14:2], other address lines should process Pull-down.



Indirect bus I/F mode related register is as below.

Value	Symbol	Description
0x00	MR	It performs the selection of Indirect bus I/F mode, address automatic increase. Refer to “4. Register Description” for more detail.
0x01 0x02	IDM_AR0 IDM_AR1	Indirect bus I/F mode address Register Big-endian use only · In case of Big-endian ordering 0x01 0x02 IDM_AR0 : MSB | IDM_AR1 : LSB Ex) In case of reading S0_CR(0x0401), 0x01(IDM_AR0) 0x02(IDM_AR1) 0x04 | 0x01
0x03	IDM_DR	Indirect bus I/F mode data Register

In order to read or write the internal register or internal TX/RX Memory,

1. Write the address to read or write on IDM_AR0, 1.
2. Read or Write IDM_DR.

In order to read or write the data on the sequential address, set AI bit of MR(Mode Register). With this, user performs above 1 only one time. Whenever read or write IDM_DR, IDM_AR , the value is automatically increased by 1. Therefore, the value can be processed on the sequential address just by continuous reading or writing of IDM_DR.

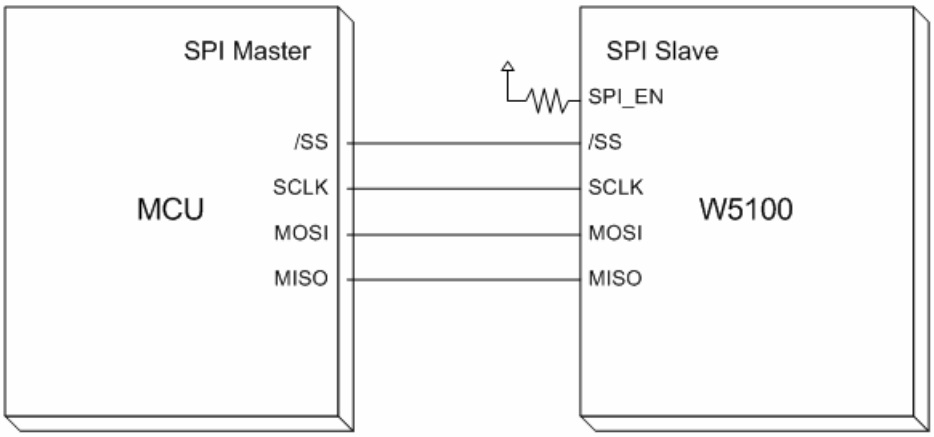
6.3 SPI (Serial Peripheral Interface) mode

Serial Peripheral Interface Mode uses only four pins for data communication.

Four pins are SCLK, /SS, MOSI, MISO.

At the W5100, SPI_EN pin is used for SPI operation.

By asserting SPI_EN pin high, A[14~11] pins turn to SCLK, /SS, MOSI, MISO pins.



6.3.1 Device Operations

The W5100 is controlled by a set of instruction that is sent from a host controller, commonly referred to as the SPI Master. The SPI Master communicates with W5100 via the SPI bus which is composed of four signal lines: Slave Select(/SS), Serial Clock(SCLK), MOSI(Master Out Slave In), MISO(Master In Slave Out).

The SPI protocol defines four modes for its operation (Mode 0, 1, 2, 3). Each mode differs according to the SCLK polarity and phase - how the polarity and phase control the flow of data on the SPI bus.

The W5100 operates as SPI Slave device and supports the most common modes - SPI Mode 0 and 3.

The only difference between SPI Mode 0 and 3 is the polarity of the SCLK signal at the inactive state. With SPI Mode 0 and 3, data is always latched in on the rising edge of SCLK and always output on the falling edge of SCLK.

6.3.2 Commands

According to SPI protocol, there are only two data lines used between SPI devices. So, it is necessary to define OP-Code. W5100 uses two types of OP-Code - Read OP-Code and Write OP-Code. Except for those two OP-Codes, W5100 will be ignored and no operation will be started.

In SPI Mode, W5100 operates in “unit of 32-bit stream”.

The unit of 32-bit stream is composed of 1 byte OP-Code Field, 2 bytes Address Field and 1 byte data Field.

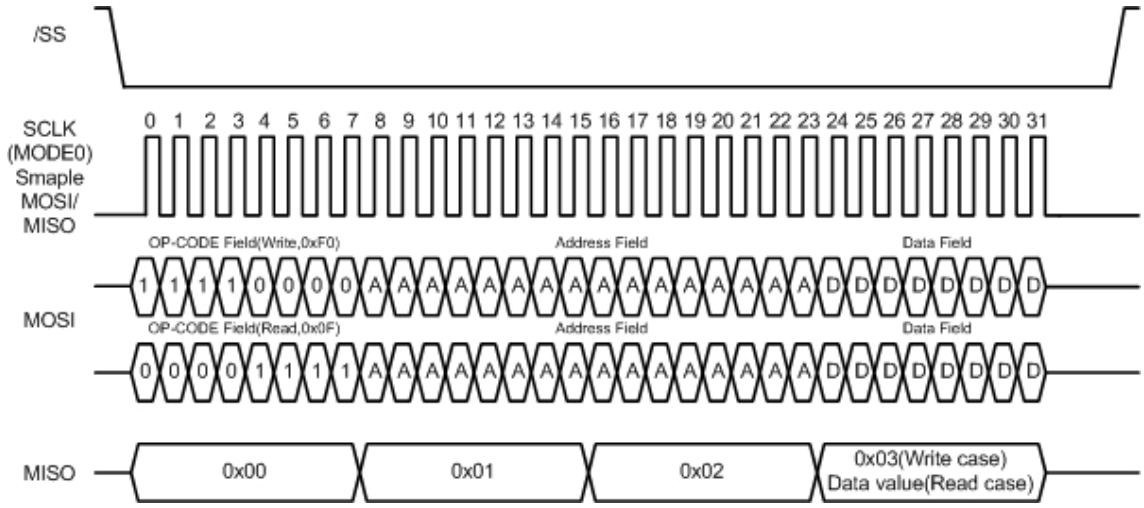
OP-Code, Address and data bytes are transferred with the most significant bit(MSB) first and least significant bit(LSB) last. In other words, the first bit of SPI data is MSB of OP-Code Field

and the last bit of SPI data is LSB of Data-Field. W5100 SPI data format is as below.

Command	OP-Code Field		Address Field	Data Field
Write operation	0xF0	1111 0000	2 bytes	1 byte
Read operation	0x0F	0000 1111	2 bytes	1 byte

6.3.3 Process of using general SPI Master device (According to SPI protocol)

1. Configure Input/Output direction on SPI Master device pins.
   * /SS (Slave Select) : Output pin
   * SCLK (Serial Clock) : Output pin
   * MOSI (Master Out Slave In) : Output pin
   * MISO (Master In Slave Out) : Input pin
2. Configure /SS as 'High'
3. Configure the registers on SPI Master device.
   * SPI Enable bit on SPCR register (SPI Control Register)
   * Master/Slave select bit on SPCR register
   * SPI Mode bit on SPCR register
   * SPI data rate bit on SPCR register and SPSR register (SPI State Register)
4. Write desired value for transmission on SPDR register (SPI Data Register).
5. Configure /SS as 'Low' (data transfer start)
6. Wait for reception complete
7. If all data transmission ends, configure /SS as 'High'



7. Electrical Specifications

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{DD}	DC Supply voltage	-0.5 to 3.6	V
V_{IN}	DC input voltage	-0.5 to 5.5 (5V tolerant)	V
I_{IN}	DC input current	±5	mA
T_{OP}	Operating temperature	0 to 80	°C
T_{STG}	Storage temperature	-55 to 125	°C

***COMMENT**: Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage.

DC Characteristics

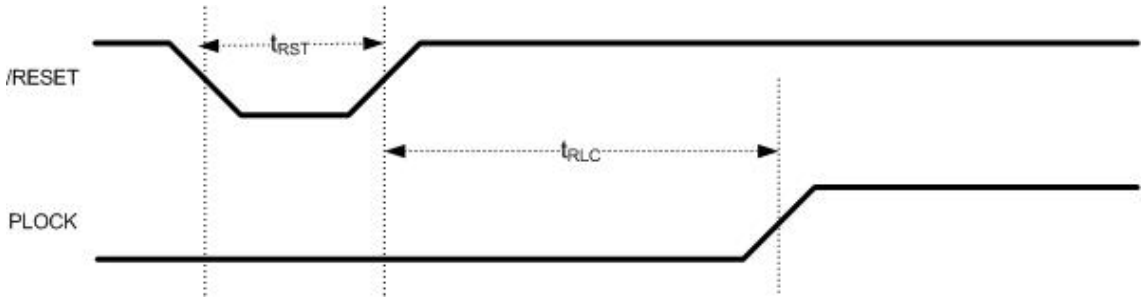
Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
V_{DD}	DC Supply voltage	Junction temperature is from -55°C to 125°C	3.0		3.6	V
V_{IH}	High level input voltage		2.0		5.5	V
V_{IL}	Low level input voltage		- 0.5		0.8	V
V_{OH}	High level output voltage	I_{OH} = 2, 4, 8, 12, 16, 24 mA	2.0		3.6	V
V_{OL}	Low level output voltage	I_{OL} = -2, -4, -8, -12, -16, -24 mA	0.0		0.4	V
I_I	Input Current	$V_{IN} = V_{DD}$			±5	μA

POWER DISSIPATION

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
P_{10Base}	Power consumption in 10BaseT					mA
$P_{100Base}$	Power consumption in 100BaseT					mA

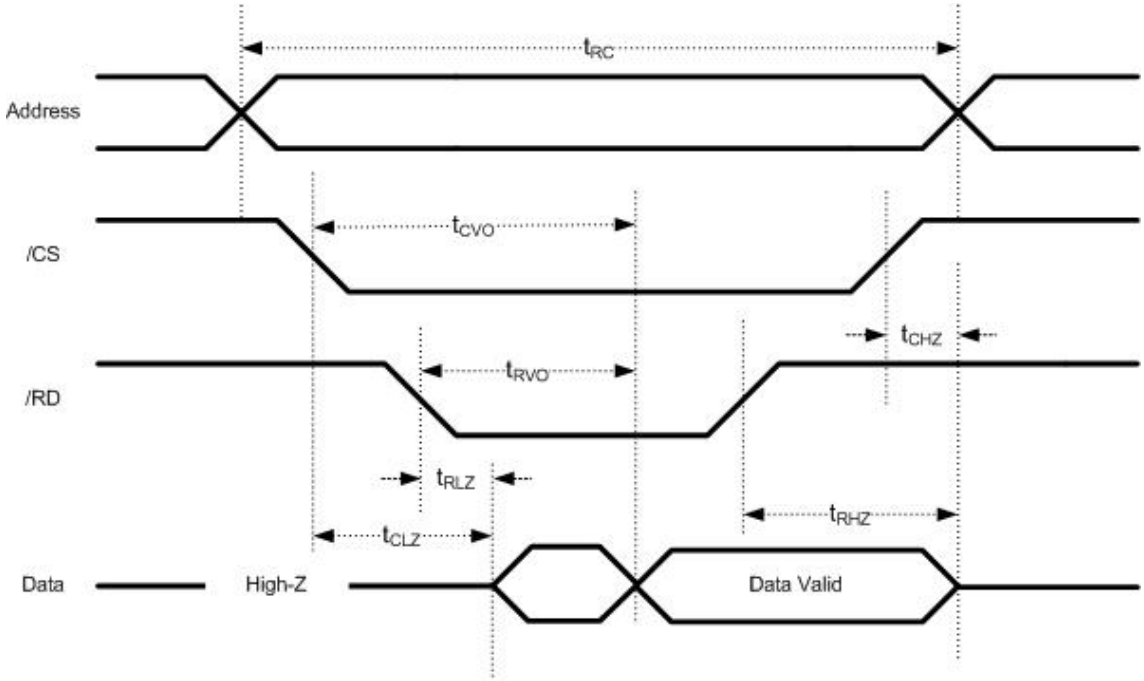
AC Characteristics

Reset Timing



Symbol	Parameter	Min	Max
t_{RST}	Reset Cycle Time	2 us	-
t_{RLC}	/RESET to internal PLOCK	-	10 ms

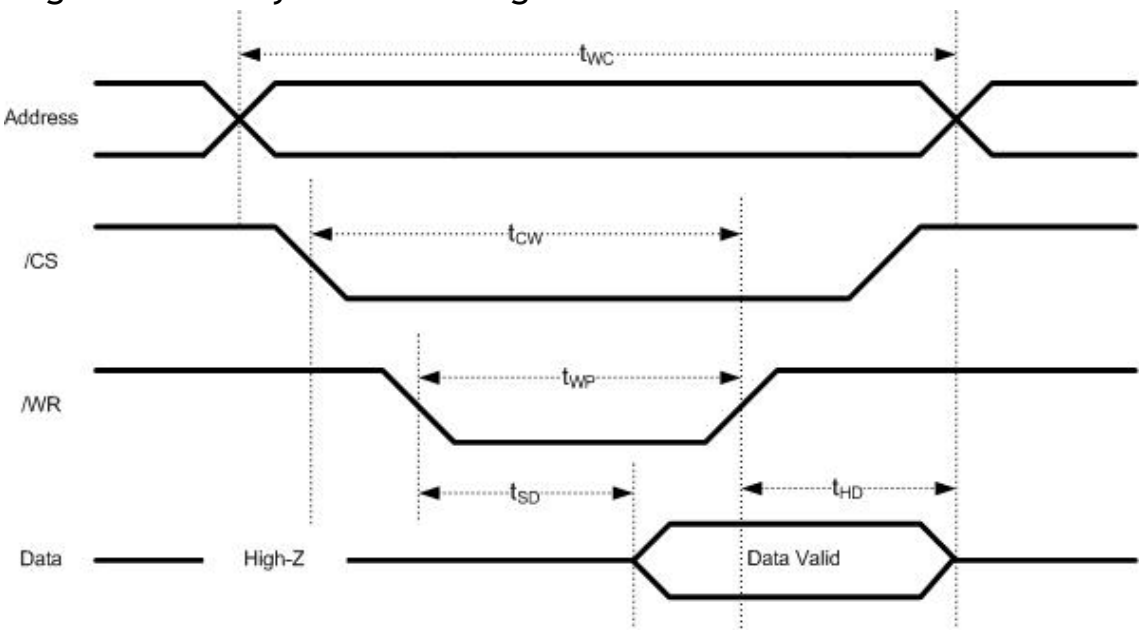
Register/Memory READ Timing



Symbol	Parameter	Min	Max
t_{RC}	Read Cycle Time	80 ns	-
t_{CVO}	/CS to Valid Output	-	80 ns

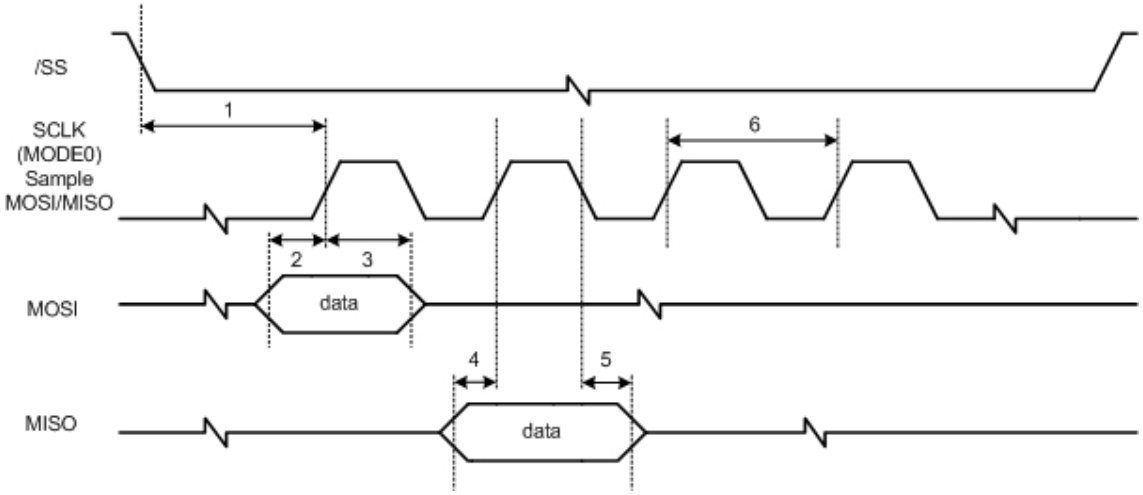
t_{RVO}	/RD to Valid Output	-	80 ns
t_{CLZ}	/CS to Low-Z Output	0 ns	-
t_{RLZ}	/RD to Low-Z Output	0 ns	-
t_{CHZ}	/CS to High-Z Output	-	1 ns
t_{RHZ}	/RD to High-Z Output	-	1 ns

Register/Memory WRITE Timing



Symbol	Parameter	Min	Max
t_{WC}	Write Cycle Time	70 ns	-
t_{CW}	/CS to Write End	70 ns	-
t_{WP}	/WR Pulse width	63 ns	-
t_{SD}	/WR low to SD valid	-	14 ns
t_{HD}	Data Hold from Write End	0 ns	-

SPI Timing



	Description	Mode	Min	Max
1	/SS low to SCLK	Slave	21 ns	-
2	Input setup time	Slave	7 ns	-
3	Input hold time	Slave	28 ns	-
4	Output setup time	Slave	7 ns	14 ns
5	Output hold time	Slave	21 ns	-
6	SLKC time	Slave	70 ns	

Crystal Characteristics

Parameter	Range
Frequency	25 MHz
Frequency Tolerance (at 25℃)	±30 ppm
Shunt Capacitance	7pF Max
Drive Level	1 ~ 500uW (100uW typical)
Load Capacitance	18pF, 20pF, 27pF, 30pF, 32pF, or specify
Operating Temperature Range	-10℃ ~ 60℃
Aging (at 25℃)	±3ppm / year Max

Transformer Characteristics

Parameter	Transmit End	Receive End
Turn Ratio	1:1	1:1
Inductance	350 uH	350 uH

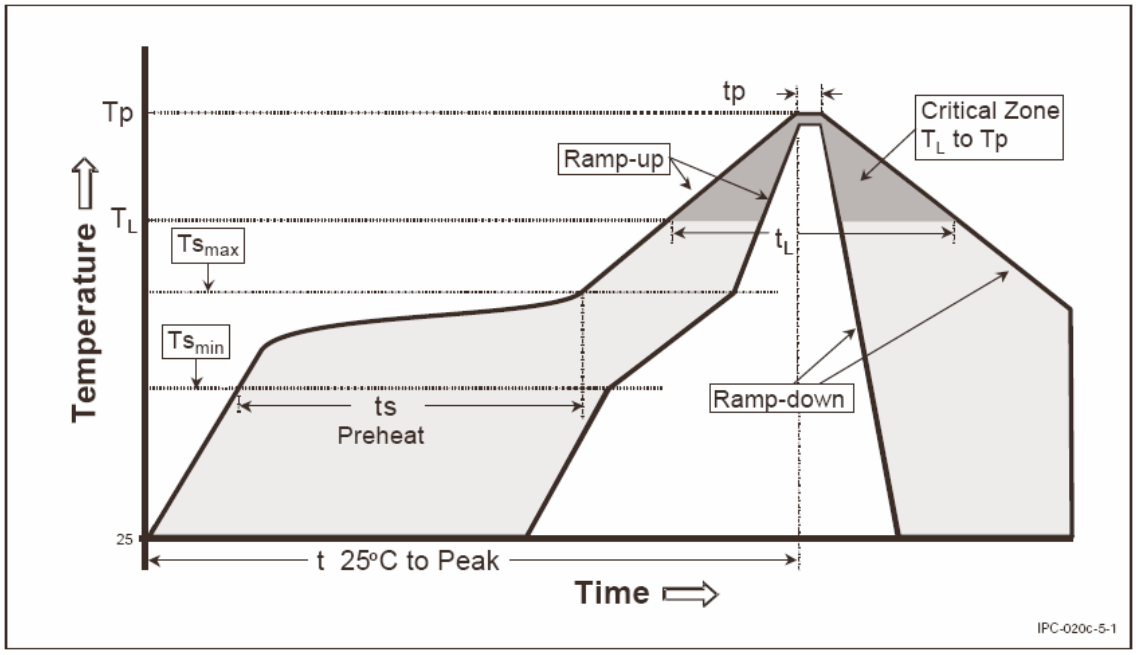
Symmetrical TX & RX channels for auto MDI/MDIX capability

8. IR Reflow Temperature Profile (Lead-Free)

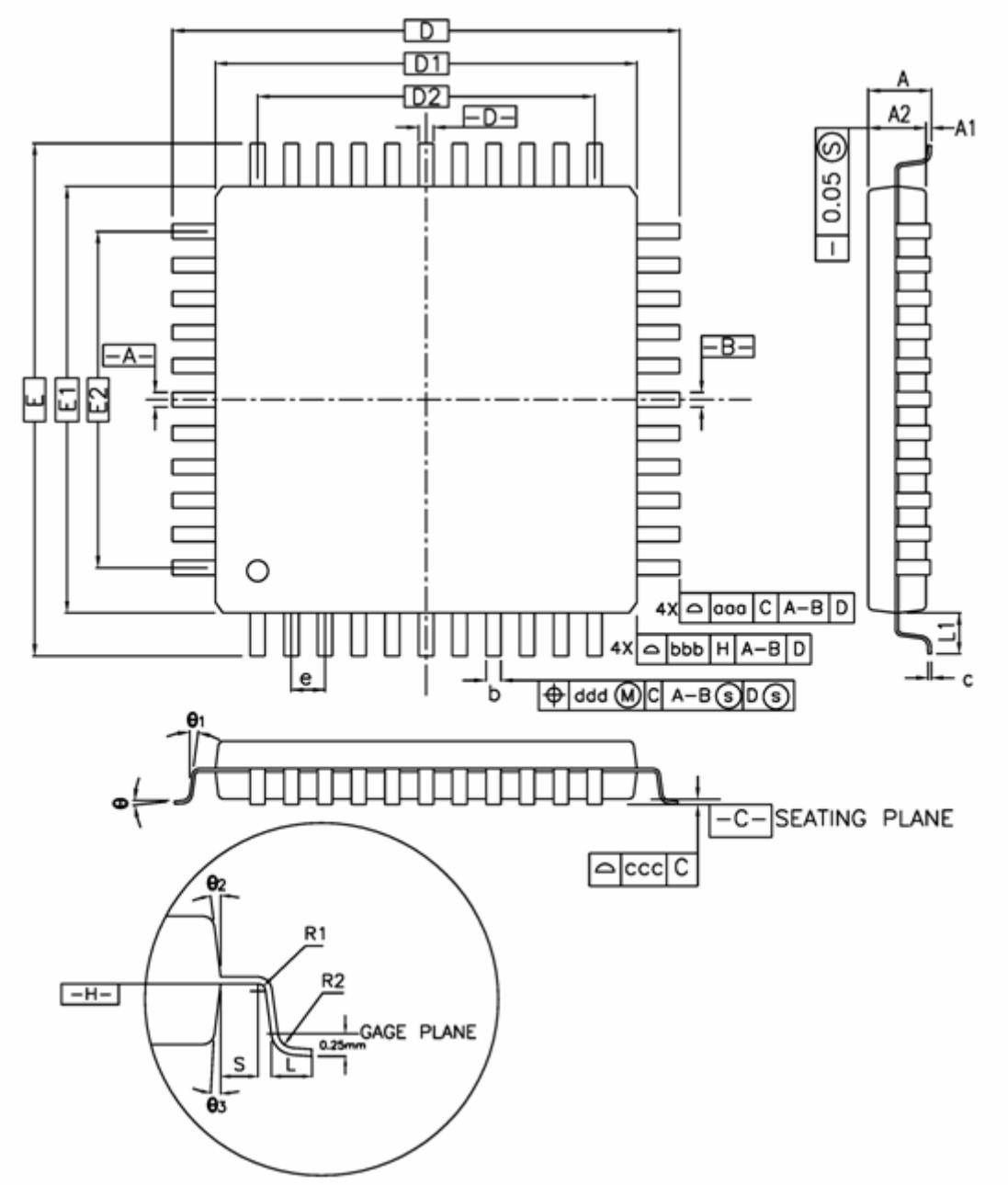
Moisture Sensitivity Level : 3

Dry Pack Required : Yes

Average Ramp-Up Rate (Ts_{max} to Tp)	3° C/second max.
Preheat – Temperature Min (Ts_{min}) – Temperature Max (Ts_{max}) – Time (ts_{min} to ts_{max})	 150 °C 200 °C 60-180 seconds
Time maintained above: – Temperature (TL) – Time (tL)	 217 °C 60-150 seconds
Peak/Classification Temperature (Tp)	260 + 0 °C
Time within 5 °C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.



9. Package Descriptions



SYMBOL	MILLIMETER			INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	-	-	1.60	-	-	0.063
A1	0.05	-	0.15	0.002	-	0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
D	12.00 BSC.			0.472 BSC.		

D1		10.00 BSC.			0.393 BSC.	
E		12.00 BSC.			0.472 BSC.	
E1		10.00 BSC.			0.393 BSC.	
R2	0.08	-	0.20	0.003	-	0.008
R1	0.08	-	-	0.003	-	-
θ	0°	3.5°	7°	0°	3.5°	7°
θ_1	0°	-	-	0°	-	-
θ_2	11°	12°	13°	11°	12°	13°
θ_3	11°	12°	13°	11°	12°	13°
c	0.09	-	0.20	0.004	-	0.008
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00 REF			0.039 REF	
S	0.20	-	-	0.008	-	-
b	0.13	0.16	0.23	0.005	0.006	0.009
e		0.40 BSC			0.016 BSC	
D2		7.60			0.299	
E2		7.60			0.299	
aaa		0.20			0.008	
bbb		0.20			0.008	
ccc		0.08			0.003	
ddd		0.07			0.003	

Note :

1. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION.
ALLOWABLE PROTRUSION IS 0.25mm PER SIDE. D1 AND E1 ARE MAXIMUM PLASTIC BODY SIZE DIMENSIONS INCLUDING MOLD MISMATCH.

2. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.
ALLOWABLE DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED THE MAXIMUM b DIMENSION BY MORE THAN 0.08mm.
DAMBAR CAN NOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND AN ADJACENT LEAD IS 0.07mm FOR 0.4mm AND 0.5mm PITCH PACKAGES.