

10/100BASE-TX/FX Mini- Φ ™ Transceiver

GENERAL DESCRIPTION

The BCM5220 is a single channel, low-power, 10/100BASE-TX/FX transceiver targeting a number of applications requiring intelligent power management and robust network tolerance. The BCM5220 operates at 3.3V or 2.5V. The devices contain a full-duplex 10BASE-T/100BASE-TX/100BASE-FX Fast Ethernet transceiver, which performs all of the physical layer interface functions for 10BASE-T Ethernet on CAT 3, 4, and 5 unshielded twisted pair (UTP) cable and 100BASE-TX Fast Ethernet on CAT 5 UTP cable. In addition, pin-compatibility with the BCM5221 offers the flexibility of an upgrade path. 100BASE-FX is supported through the use of external fiber-optic transmit and receive devices.

The BCM5220 is a highly integrated solution combining a digital adaptive equalizer, ADC, phase lock loop, line driver, encoder, decoder and all the required support circuitry into a single monolithic CMOS chip. It complies fully with the IEEE 802.3u specification, including the Media Independent Interface (MII) and Auto-Negotiation subsections.

The effective use of digital technology in the BCM5220 design results in robust performance over a broad range of operating scenarios. Problems inherent to mixed-signal implementations, such as analog offset and on-chip noise, are eliminated by employing field proven digital adaptive equalization and digital clock recovery techniques.

FEATURES

- Power Supply: 2.5V or 3.3V
- Integrated Voltage Regulator to Allow Operation from a Single Supply Source
- Power Consumption: <275 mW
- Unique Energy Detection Circuit to Enable Intelligent Power Management
- Cable Length Indication
- Cable Noise Level Indication
- Robust CESD Tolerance
- Cable Length Greater Than 140 meters
- Well Under 10 PPM Defect Ratio Quality
- +10% Voltage Tolerance
- Industrial Temperature Range (-40 to 85C)
- MII and 7-wire Serial Interface Configurable
- IEEE 1149.1 (JTAG) Scan Chain Support
- MII Management Via Serial Port
- Pin-compatible with BCM5221
- 10BASE-T/100BASE-TX/FX IEEE 802.3u Fast Ethernet Transceiver
- 64-pin TQFP or 64-pin BGA Package

APPLICATIONS

- PCMCIA/CardBus cards
- LAN on motherboard
- IP phones
- Cable modems
- Set-top boxes and print servers
- Wireless access points
- Embedded telecom

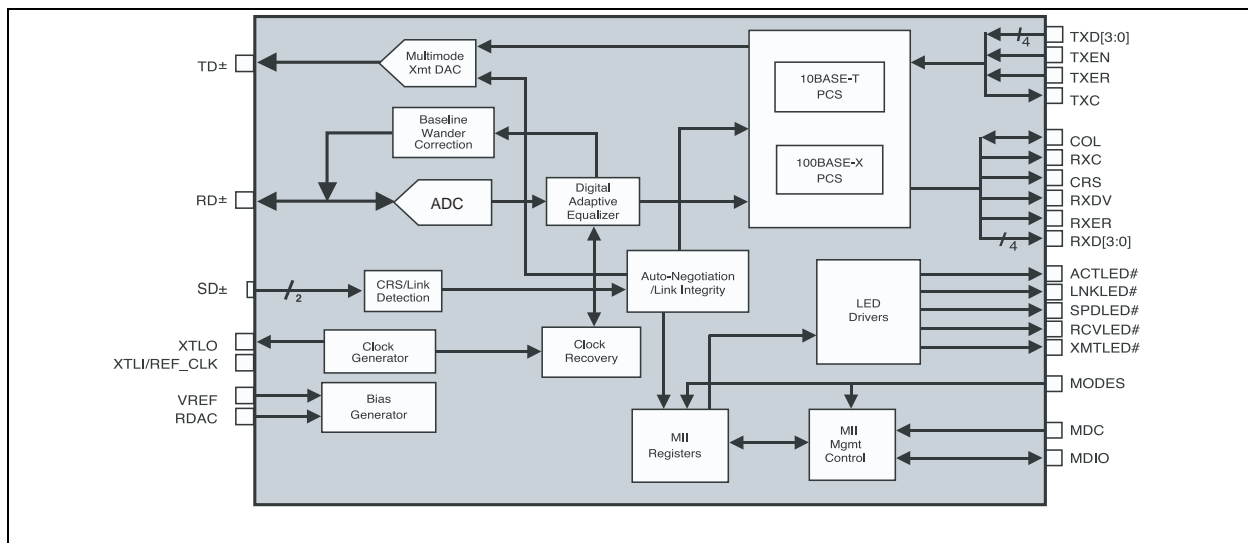


Figure 1: Functional Block Diagram

REVISION HISTORY

Revision #	Date	Change Description
5520-DS04-405-R	04/20/04	Added RMII timing information to "Timing and AC Characteristics" on page 58.
5220-DS03-R	09/30/02	Replaced Functional Block Diagram on cover page. Modified various function descriptions in Table 3. Modified various function descriptions in Table 9. Modified various values in Table 37. Deleted Tables 50 through 53. Deleted Figures 17 and 18.
5220-DS02-R	05/25/01	Page 14, 17 and 49 - Clarified power on reset requirement. Page 10 Pin Descriptions- added sentence to pin H8 and G8. Page 16 - Added Separate 100BASE-TX and 10BASE Link sentence to Special LED Modes. Page 21 - Added Alt Link Mode to bit 12 of Auxiliary Mode in Table 7. Page 42 - Added bits 11:5, and 12 to Table 28.
5220-DS01-R	03/02/01	Eliminated XTALVDD references. Changed Advanced Specifications to Preliminary Specifications. Deleted CK25 from PHYAD4. Removed TXDAC power mode bit from MII registers 18h bit 8, table 7. Changed default value of MII register 1Ah, table 7. Added bit 15, FDX LED enable to MII register 1Ah, table 25. Fixed several register definitions and moved them to correct tables. Added timing and power values to parameters in table 40 through 57. Added thermal characteristics section. Updated table 57, electrical characteristics. Updated pin label descriptions for XTALI/XTALO and energy_det in table 3. Updated PHY identifier registers section by changing 00h to 0h in paragraph under table 11. Updated descriptions for LEDs H8 and G8 in table 3, Pin descriptions.
5220-DS00-R	10/01/00	Initial Release.

Broadcom Corporation
P.O. Box 57013
16215 Alton Parkway
Irvine, CA 92619-7013
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Section 1: Functional Description

OVERVIEW

The BCM5220 is a single-chip Fast Ethernet transceiver. It performs all of the physical layer interface functions for 100BASE-TX full-or half-duplex Ethernet on CAT 5 twisted pair cable and 10BASE-T full-or half-duplex Ethernet on CAT 3, 4 or 5 cable. It may also be configured for 100BASE-FX full-or half-duplex transmission over fiber-optic cabling when paired with an external fiber-optic line driver and receiver.

The chip performs 4B5B, MLT3, NRZI, and Manchester encoding and decoding, clock and data recovery, stream cipher scrambling/descrambling, digital adaptive equalization, line transmission, carrier sense and link integrity monitor, auto-negotiation and Media Independent Interface (MII) management functions. The BCM5220 can be connected to a MAC switch controller through the MII on one side, and connects directly to the network media on the other side (through isolation transformers for unshielded twisted pair (UTP) modes or fiber-optic transmitter/receiver components for FX modes). The BCM5220 is fully compliant with the IEEE 802.3 and 802.3u standards.

ENCODER/DECODER

In 100BASE-TX and 100BASE-FX modes, the BCM5220 transmits and receives a continuous data stream on twisted-pair or fiber-optic cable. When the MII transmit enable is asserted, nibble-wide (4-bit) data from the transmit data pins is encoded into 5-bit code groups and inserted into the transmit data stream. The 4B5B encoding is shown in Table 1 on page 5. The transmit packet is encapsulated by replacing the first 2 nibbles of preamble with a start of stream delimiter (J/K codes) and appending an end of stream delimiter (T/R codes) to the end of the packet. When the MII transmit error input is asserted during a packet, the transmit error code group (H) is sent in place of the corresponding data code group. The transmitter repeatedly sends the idle code group between packets.

In TX mode, the encoded data stream is scrambled by a stream cipher block and then serialized and encoded into MLT3 signal levels. A multi-mode transmit DAC is used to drive the MLT3 data onto the twisted pair cable. In FX mode, the scrambling function is bypassed and the data is NRZI encoded. The multimode transmit DAC drives differential positive ECL (PECL) levels to an external fiber-optic transmitter.

Following baseline wander correction, adaptive equalization, and clock recovery in TX mode, the receive data stream is converted from MLT3 to serial NRZ data. The NRZ data is descrambled by the stream cipher block and then deserialized and aligned into 5-bit code groups.

In FX mode, the receive data stream differential PECL levels are sampled from the fiber-optic receiver. Baseline wander correction, adaptive equalization, and stream cipher descrambling functions are bypassed and NRZI decoding is used instead of MLT3.

The 5-bit code groups are decoded into 4-bit data nibbles, as shown in Table 1. The start of stream delimiter is replaced with preamble nibbles and the end of stream delimiter and idle codes are replaced with all zeros. The decoded data is driven onto the MII receive data pins. When an invalid code group is detected in the data stream, the BCM5220 asserts the MII RXER signal. The chip also asserts RXER for several other error conditions that improperly terminate the data stream. While RXER is asserted, the receive data pins are driven with a 4-bit code indicating the type of error detected. The error codes are listed in Table 2 on page 6.

In 10BASE-T mode, Manchester encoding and decoding is performed on the data stream. The multimode transmit DAC performs pre-equalization for 100 meters of CAT 3 cable.

LINK MONITOR

In 100BASE-TX mode, receive signal energy is detected by monitoring the receive pair for transitions in the signal level. Signal levels are qualified using squelch detect circuits. When no signal or certain invalid signals are detected on the receive pair, the link monitor enters and remains in the link fail state, where only idle codes are transmitted. When a valid signal is detected on the receive pair for a minimum period of time, the link monitor enters the link pass state and the transmit and receive functions are enabled.

In 100BASE-FX mode, the external fiber-optic receiver performs the signal energy detection function and communicates this information directly to the BCM5220 through the differential SD_{\pm} pins.

In 10BASE-T mode, a link-pulse detection circuit constantly monitors the RD_{\pm} pins for the presence of valid link pulses.

CARRIER SENSE

In 100BASE-X modes, carrier sense is asserted asynchronously on the CRS pin as soon as activity is detected in the receive data stream. RXDV is asserted as soon as a valid Start-of-Stream Delimiter (SSD) is detected. Carrier sense and RXDV are deasserted synchronously upon detection of a valid end of stream delimiter or two consecutive idle code groups in the receive data stream. If carrier sense is asserted and a valid SSD is not detected immediately, then RXER is asserted in place of RXDV. A value of 1110 is driven on the receive data pins to indicate false carrier sense.

In 10BASE-T mode, carrier sense is asserted asynchronously on the CRS pin when valid preamble activity is detected on the $RD_{+/-}$ input pins.

In half-duplex DTE mode, the BCM5220 asserts carrier sense while transmit enable is asserted and the link monitor is in the Pass state. In full-duplex mode, CRS is only asserted for receive activity.

COLLISION DETECTION

In half-duplex mode, collision detect is asserted on the COL pin whenever carrier sense is asserted and transmission is in progress.

AUTO-NEGOTIATION

The BCM5220 contains the ability to negotiate its mode of operation over the twisted pair link using the auto-negotiation mechanism defined in the IEEE 802.3u specification. Auto-negotiation can be enabled or disabled by hardware or software control. When the auto-negotiation function is enabled, the BCM5220 automatically chooses its mode of operation by advertising its abilities and comparing them with those received from its link partner.

The BCM5220 can be configured to advertise 100BASE-TX full-duplex and/or half-duplex and 10BASE-T full-and/or half-duplex. The transceiver negotiates with its link partner and chooses the highest level of operation available for its own link. Auto-negotiation is not operational during 100BASE-FX operation.

DIGITAL ADAPTIVE EQUALIZER

The digital adaptive equalizer removes Intersymbol Interference (ISI) created by the transmission channel media. The equalizer accepts sampled unequalized data from the ADC on each channel and produces equalized data. The BCM5220 achieves an optimum signal-to-noise ratio by using a combination of feed forward equalization and decision feedback equalization. This powerful technique achieves a 100BASE-TX BER of less than 1×10^{-12} for transmission up to 100 meters on CAT 5 twisted pair cable, even in harsh noise environments. The digital adaptive equalizers in the BCM5220 achieve performance close to theoretical limits. The all-digital nature of the design makes the performance very tolerant to on-chip noise. The filter coefficients are self-adapting to any quality of cable or cable length. Due to transmit pre-equalization in 10BASE-T mode and complete lack of ISI in 100BASE-FX mode, the adaptive equalizer is bypassed in these two modes of operation.

ADC

The receive channel has a 6-bit, 125-MHz analog-to-digital converter (ADC). The ADC samples the incoming data on the receive channel and produces a 6-bit output. The output of the ADC is fed to the digital adaptive equalizer. Advanced analog circuit techniques achieve low-offset, high-power-supply noise rejection, fast settling time, and low bit error rate.

DIGITAL CLOCK RECOVERY/GENERATOR

The all-digital clock recovery and generator block creates all internal transmit and receive clocks. The transmit clock is locked to the 25-MHz clock input, while the receive clock is locked to the incoming data stream. Clock recovery circuits optimized to MLT3, NRZI, and Manchester encoding schemes are included for use with each of the three different operating modes. The input data stream is sampled by the recovered clock and fed synchronously to the digital adaptive equalizer.

BASELINE WANDER CORRECTION

A 100BASE-TX data stream is not always DC balanced. Because the receive signal must pass through a transformer, the DC offset of the differential receive input can wander. This effect, known as baseline wander, can greatly reduce the noise immunity of the receiver. The BCM5220 automatically compensates for baseline wander by removing the DC offset from the input signal, and thereby significantly reduces the chance of a receive symbol error.

The baseline wander correction circuit is not required, and therefore is bypassed, in 10BASE-T and 100BASE-FX operating modes.

MULTIMODE TRANSMIT DAC

The multimode transmit digital-to-analog converter (DAC) transmits MLT3-coded symbols in 100BASE-TX mode, NRZI-coded symbols in 100BASE-FX mode, and Manchester-coded symbols in 10BASE-T mode. It allows programmable edge-rate control in TX mode, which decreases unwanted high frequency signal components, thus reducing EMI. High-frequency pre-emphasis is performed in 10BASE-T mode; no filtering is performed in 100BASE-FX mode. The transmit DAC utilizes a current drive output, which is well balanced and produces very low noise transmit signals. PECL voltage levels are produced with resistive terminations in 100BASE-FX mode.

STREAM CIPHER

In 100BASE-TX mode, the transmit data stream is scrambled to reduce radiated emissions on the twisted-pair cable. The data is scrambled by exclusive ORing the NRZ signal with the output of an 11-bit-wide linear feedback shift register (LFSR), which produces a 2047-bit non-repeating sequence. The scrambler reduces peak emissions by randomly spreading the signal energy over the transmit frequency range and eliminating peaks at certain frequencies.

The receiver descrambles the incoming data stream by exclusive ORing it with the same sequence generated at the transmitter. The descrambler detects the state of the transmit LFSR by looking for a sequence representing consecutive idle codes. The descrambler locks to the scrambler state after detecting a sufficient number of consecutive idle code-groups. The receiver does not attempt to decode the data stream unless the descrambler is locked. When locked, the descrambler continuously monitors the data stream to make sure that it has not lost synchronization. The receive data stream is expected to contain inter-packet idle periods. If the descrambler does not detect enough idle codes within 724 μ s, it becomes unlocked, and the receive decoder is disabled. The descrambler is always forced into the unlocked state when a link failure condition is detected.

A special node called High Speed Token Ring can be enabled. It increases the scrambler timeout from 724 μ s to 5816 μ s, thus allowing frames as large as the Token Ring maximum length to be received without error.

Stream cipher scrambling/descrambling is not used in 100BASE-FX and 10BASE-T modes.

FAR-END FAULT

Auto-negotiation provides a remote fault capability for detection of asymmetric link failures. Since auto-negotiation is not available for 100BASE-FX, the BCM5220 implements the IEEE 802.3 standard Far-End Fault mechanism for the indication and detection of remote error conditions. When the Far-End Fault mechanism is enabled, a transceiver transmits the Far-End Fault Indication whenever a receive channel failure is detected (signal detect is deasserted). The transceiver also continuously monitors the receive channel when a valid signal is present (signal detect asserted). When its link partner is indicating a remote error, the transceiver forces its link monitor into the link fail state and sets the remote fault bit in the MII status register.

The Far-End Fault mechanism is enabled by default in 100BASE-FX mode and disabled in 100BASE-TX and 10BASE-T modes, and can be controlled by software after reset.

MII MANAGEMENT

The BCM5220 contains a complete set of MII management registers accessible by using the management clock line (MDC) and the bidirectional serial data line (MDIO). Many transceivers can be bussed together on a single MDIO/MDC wire pair by giving each a unique PHY address, defined by configuring the five external PHY address input pins.

Every time an MII read or write operation is executed, the BCM5220 compares the operation's PHY address with its own PHY address definition. The operation is executed only when the addresses match.

For further details, see Section 5: "Register Summary" on page 18.

Table 1: 4B5B Encoding

Name	4B code	5B Code	Meaning
0	0000	11110	Data 0
1	0001	01001	Data 1
2	0010	10100	Data 2
3	0011	10101	Data 3
4	0100	01010	Data 4
5	0101	01011	Data 5
6	0110	01110	Data 6
7	0111	01111	Data 7
8	1000	10010	Data 8
9	1001	10011	Data 9
A	1010	10110	Data A
B	1011	10111	Data B
C	1100	11010	Data C
D	1101	11011	Data D
E	1110	11100	Data E
F	1111	11101	Data F
I	0000*	11111	Idle
J	0101*	11000	Start-of-Stream Delimiter, Part 1

Table 1: 4B5B Encoding (Cont.)

Name	4B code	5B Code	Meaning
K	0101*	10001	Start-of-Stream Delimiter, Part 2
T	0000*	01101	End-of-Stream Delimiter, Part 1
R	0000*	00111	End-of-Stream Delimiter, Part 2
H	1000	00100	Transmit Error (used to force signalling errors)
V	0111	00000	Invalid Code
V	0111	00001	Invalid Code
V	0111	00010	Invalid Code
V	0111	00011	Invalid Code
V	0111	00101	Invalid Code
V	0111	00110	Invalid Code
V	0111	01000	Invalid Code
V	0111	011000	Invalid Code
V	0111	10000	Invalid Code
V	0111	11001	Invalid Code

* Treated as invalid code (mapped to 0111) when received in data field.

Table 2: Receive Error Encoding

Error Type	RXD[3:0]
Stream cipher error—descrambler lost lock	0010
Link failure	0011
Premature end of stream	0110
Invalid code	0111
Transmit error	1000
False carrier sense	1110

Section 2: Hardware Signal Definition Table

Table 3 provides the pin descriptions for the BCM5220.

Table 3: Pin Descriptions

5220KPB	5220KPT	Pin Label	Type	Description
MEDIA Connections				
H4	26	RD+	I	Receive Pair. Differential data from the media is received on the RD± signal pair.
G4	25	RD-		
H5	31	TD+	O	Transmit Pair. Differential data is transmitted to the media on the TD± signal pair.
G5	30	TD-		
Clock				
D1	6	XTALI	I	Crystal Input, Output for MII Mode Only. If these pins are used, then REF_CLK must be left open. A 25-MHz, parallel-resonant crystal can be connected between these pins. Accuracy of the crystal is ± 50 ppm. Connect an appropriate value capacitor from each pin to GND. Whenever REF_CLK pin is used, ground XTALI pin and leave XTALO pin unconnected.
C1	5	XTALO	O	
B1	4	REF_CLK	I _{PD}	MII 25-MHz Reference Clock Input. Whenever REF_CLK pin is used, ground XTALI pin and leave XTALO pin unconnected. This pin must be driven with a continuous 25-MHz clock. Accuracy is +/-50 ppm, with a duty cycle between 35% and 65% inclusive. This pin must be left unconnected when using pins XTALI and XTALO.
MII Interface				
B6	53	TXC	O _{3S}	Transmit Clock. 25-MHz output in 100BASE-X mode and 2.5 MHz in 10BASE-T MII mode. 10-MHz output in 10BASE-T serial mode. This clock is a continuously driven output, generated from the XTALI input.
B4	60	TXD3	I _{PD}	MII Transmit Data Input. Nibble-wide transmit data stream is input on these pins synchronous with TXC. TXD[3] is the most significant bit. Only TXD0 is used in 10BASE-T serial mode.
B5	59	TXD2		
A4	58	TXD1		
A5	57	TXD0		
A6	56	TXEN	I _{PD}	MII Transmit Enable. Active high. Indicates that the data nibble on TXD[3:0] is valid.
A7	52	TXER	I _{PD}	MII Transmit Error. An active high input is asserted when a transmit error condition is requested by the MAC.
B7	50	RXC	O _{3S}	MII Receive Clock. 25-MHz output in 100BASE-X MII mode and 2.5-MHz output in 10BASE-T mode. 10-MHz output in 10BASE-T serial mode. This clock is recovered from the incoming data on the cable inputs. RXC is a continuously running output clock resynchronized at the start of each incoming packet. This synchronization may result in an elongated period during one cycle while RXDV is low.
E8	43	RXD3	O _{3S}	MII Receive Data Outputs. Nibble-wide receive data stream is driven out on these pins synchronous with RXC. RXD[3] is the most significant bit. Only RXD0 is used in 10BASE-T serial mode.
D8	44	RXD2		
C8	47	RXD1		
B8	48	RXD0		

[MSB:LSB]; # = active-low signal, I = input, O = output, I/O = bidirectional, I_{PU} = input w/ internal pull-up, O_{OD} = open-drain output, O_{3S} = three-state output, B = Bias, PWR = power supply, GND = ground



Table 3: Pin Descriptions (Cont.)

5220KPB	5220KPT	Pin Label	Type	Description
C6	49	RXDV	O _{3S}	MII Receive Data Valid. Active high. Indicates that a receive frame is in progress, and that the data stream present on the RXD output pins is valid.
A8	51	RXER	O _{3S}	MII Receive Error Detected. Active high. Indicates that an error is occurring during a receive frame.
A3	62	CRS/ CRS_DV	O _{3S}	MII Carrier Sense. Active high. Indicates traffic on link. In 100BASE-X modes, CRS is asserted when a non-idle condition is detected in the receive data stream and deasserted when idle or a valid end of stream delimiter is detected. In 10BASE-T mode, CRS is asserted when a valid preamble is detected and deasserted when end-of-file or an idle condition is detected. CRS is also asserted during transmission of packets except in full-duplex modes. CRS is an asynchronous output signal.
B3	61	COL	O _{3S}	Collision Detect. In half-duplex modes, active high output indicates that a collision has occurred. In full-duplex mode, COL remains low. COL is an asynchronous output signal.
E6	41	MDIO	I/O _{PU}	Management Data I/O. This serial input/output bit is used to read from and write to the MII registers. The data value on the MDIO pin is valid and latched on the rising edge of MDC.
D7	42	MDC	I _{PD}	Management Data Clock. The MDC clock input must be provided to allow MII management functions. Clock frequencies up to 12.5 MHz are supported.
Mode				
D2	9	RESET#	I _{PU}	Reset. Active Low. Resets the BCM5220. Also used to enable Power Off and Low Power modes.
E3	14	PHYAD4	I/O _{PD}	PHY Address Selects PHYAD[4:0]. These inputs set the MII management PHY address. These pins are sampled only during power-on reset. During normal operation these pins become outputs. PAUSE. Status of the link partner's PAUSE bit, bit 10d of MII Link Partner Ability register 05d. Activity LED. Active low. The activity LED is driven low for approximately 80 ms each time there is receive or transmit activity while in the link pass state. Collision Detect LED. Active low. This is a stretched COL signal (pin 61) that is suitable for LED display. Full-Duplex LED. The Full-Duplex LED is driven low when operating in full-duplex mode and driven high in half-duplex mode.
E2	13	PHYAD3/PAUSE		
D3	12	PHYAD2/ ACT_LED#		
D5	11	PHYAD1/ COL_LED#		
C4	10	PHYAD0/ FDX_LED#		
F8	39	FDX	I _{PD}	Full-Duplex Mode. When auto-negotiation is disabled, the FDX pin is logically ORed with register 00, bit 8 to select full-duplex (1) or half-duplex (0) operation.
[MSB:LSB]; # = active-low signal, I = input, O = output, I/O = bidirectional, I _{PU} = input w/ internal pull-up, O _{OD} = open-drain output, O _{3S} = three-state output, B = Bias, PWR = power supply, GND = ground				



Table 3: Pin Descriptions (Cont.)

5220KPB	5220KPT	Pin Label	Type	Description
F6	37	F100 TCK	I _{PU}	Force 100BASE-X Control. When 100BASE-FX mode is not selected, the F100 function is enabled. When F100 is high and ANEN is low, the transceiver is forced to 100BASE-TX operation. When F100 is low and ANEN is low, the transceiver is forced to 10BASE-T operation. When ANEN is high, F100 has no effect on operation. Test Clock. This pin becomes TCK if JTAG_EN pin is high. Clock input used to synchronize JTAG TAP control and data transfers.
F7	38	ANEN TRST#	I _{PU}	Auto-Negotiation Enable. When 100BASE-FX is not selected, the ANEN function is enabled. ANEN is active high. When pulled high, auto-negotiation begins immediately after reset. When low, auto-negotiation is disabled by default. Test Reset. This pin becomes TRST# if JTAG_EN pin is high. Asynchronous active low reset input to the JTAG TAP Controller. Must be set low to ensure the TAP Controller initializes to the test-logic-reset state.
G2 G1	21 19	SD+ SD-	I _{PD}	100BASE-FX Signal Detect. 100BASE-FX mode is selected if SD+/- pins are presented with a valid PECL differential signal. Leaving this pin unconnected or connecting them to ground causes the BCM5220 to operate in TX mode. When 100BASE-FX is selected, SD+ and SD- indicate signal quality status on the fiber optic link. When the signal quality is good, the SD+ pin will be high relative to the SD- pin.
E4	15	TESTEN	I _{PD}	Test Mode Enable. Active high. Can float or be grounded for normal operation.
F1	16	LOW_PWR	I _{PD}	Low Power Mode Enable. Active high input places the BCM5220 into Low Power operation with the chip deactivated except for the energy detect block and the crystal oscillator. When asserted with RESET# pulled low, the entire chip is deactivated (Power Off mode).
F2	17	ENERGY_DET	O _{3S}	Energy Detection. Active high output indicates the presence of a signal on RD+/- receive analog wire pair. Operational in all modes of operation except IDDQ.
Bias				
H3	23	RDAC	B	DAC Bias Resistor. Adjusts the current level of the transmit DAC. A resistor of 1.27 k Ω \pm 1% must be connected between the RDAC pin and GND.
LEDs				
H8	35	LNKLED# TDI	I/O _{PU}	Link Integrity LED. The Link Integrity LED indicates the link status of the PHY. LNKLED# is driven low when the link to the PHY is good. When bit 12 of register 1Dh is set to 1, LNKLED# is driven low when the 100BASE-TX link is good. Test Data Input. This pin becomes TDI if JTAG_EN is high. Serial data input to the JTAG TAP controller. This pin is sampled on the rising edge of TCK.

[MSB:LSB]; # = active-low signal, I = input, O = output, I/O = bidirectional, I_{PU} = input w/ internal pull-up, O_{OD} = open-drain output, O_{3S} = three-state output, B = Bias, PWR = power supply, GND = ground

Table 3: Pin Descriptions (Cont.)

5220KPB	5220KPT	Pin Label	Type	Description
G8	36	SPDLED# ADV_PAUSE# TMS	I/O _{PU}	<p>100BASE-X LED. The 100BASE-X LED is driven low when operating in 100BASE-X modes and high when operating in 10BASE-T modes. When bit 12 of register 1Dh is set to 1, SPDLED# is driven low when the 100BASE-T link is good.</p> <p>ADV_PAUSE#. Active low. During power-on reset, this pin is sampled and causes the default value of MII auto-negotiation Advertisement register, 4, bit 10d to be set accordingly.</p> <p>Test Mode Select. This pin becomes TMS if JTAG_EN is high. Single control input to the JTAG TAP controller is used to traverse the test-logic state machine. Sampled on the rising edge of TCK.</p>
G7	34	XMTLED# INTR# FDXLED#	O _{OD}	<p>Transmit Activity LED. Active low output. The transmit activity LED is driven low for approximately 80 ms each time there is transmit activity while in the link pass state. When the interrupt mode is enabled, pin becomes INTR#. When FDXLED mode is enabled, pin becomes FDXLED#.</p>
H7	33	RCVLED# ACTLED# TDO	I/O _{PU}	<p>Receive Activity LED. Active low output. The receive activity LED is driven low for approximately 80 ms each time there is receive activity while in the link pass state. In either interrupt or FDXLED mode, pin becomes ACTLED#, indicating both receive and transmit activity.</p> <p>Test Data Output. This pin becomes TDO if JTAG_EN is high. Serial data output from the JTAG TAP controller. Updated on the falling edge of TCK.</p>
JTAG				
A2	64	JTAG_EN	I _{PD}	<p>JTAG Enable. Active high. When high causes the BCM5220 to enter JTAG test mode. For normal operation leave this pin unconnected.</p>
Power				
A1	3	REGDVDD	PWR	<p>Digital Voltage Regulator Input. Connect this pin to a digital 3.3V supply.</p>
H1	20	REGAVDD	PWR	<p>Analog Voltage Regulator Input. Connect this pin to an analog 3.3V supply.</p>
C3, C5	2, 55	DVDD	PWR	<p>Digital Regulator output (2.5V). Connect these pins to decoupling capacitors as shown in Figure 18 on page 73.</p>
F4, F5	27, 28	AVDD	PWR	<p>Analog Regulator output VDD (2.5V). Connect these pins to decoupling capacitors as shown in Figure 18 on page 73.</p>
B2, E7, F3	1, 46, 18	OVDD	PWR	<p>3.3V Digital Periphery (Output Buffer) VDD supply.</p>
C7, D4, D6, E5	40, 45 54, 63	DGND	GND	<p>Digital Ground.</p>
G6, H6	29, 32	AGND	GND	<p>Analog Ground.</p>
E1	7	XTALGND	GND	<p>Crystal Ground.</p>
H2	22	BIASVDD	PWR	<p>BIAS VDD. Connect this pin to AVDD.</p>
G3	24	BIASGND	GND	<p>Bias Ground. Connect this pin to AGND.</p>
C2	8	OVDD/NC	PWR	<p>This pin is for factory test only. For normal operation, leave this pin unconnected or connect to OVDD supply</p>
<p>[MSB:LSB]; # = active-low signal, I = input, O = output, I/O = bidirectional, I_{PU} = input w/ internal pull-up, O_{OD} = open-drain output, O_{3S} = three-state output, B = Bias, PWR = power supply, GND = ground</p>				

Section 3: Pinout Diagram

Figure 1 below provides the pinout diagram for the BCM5220KPB package.

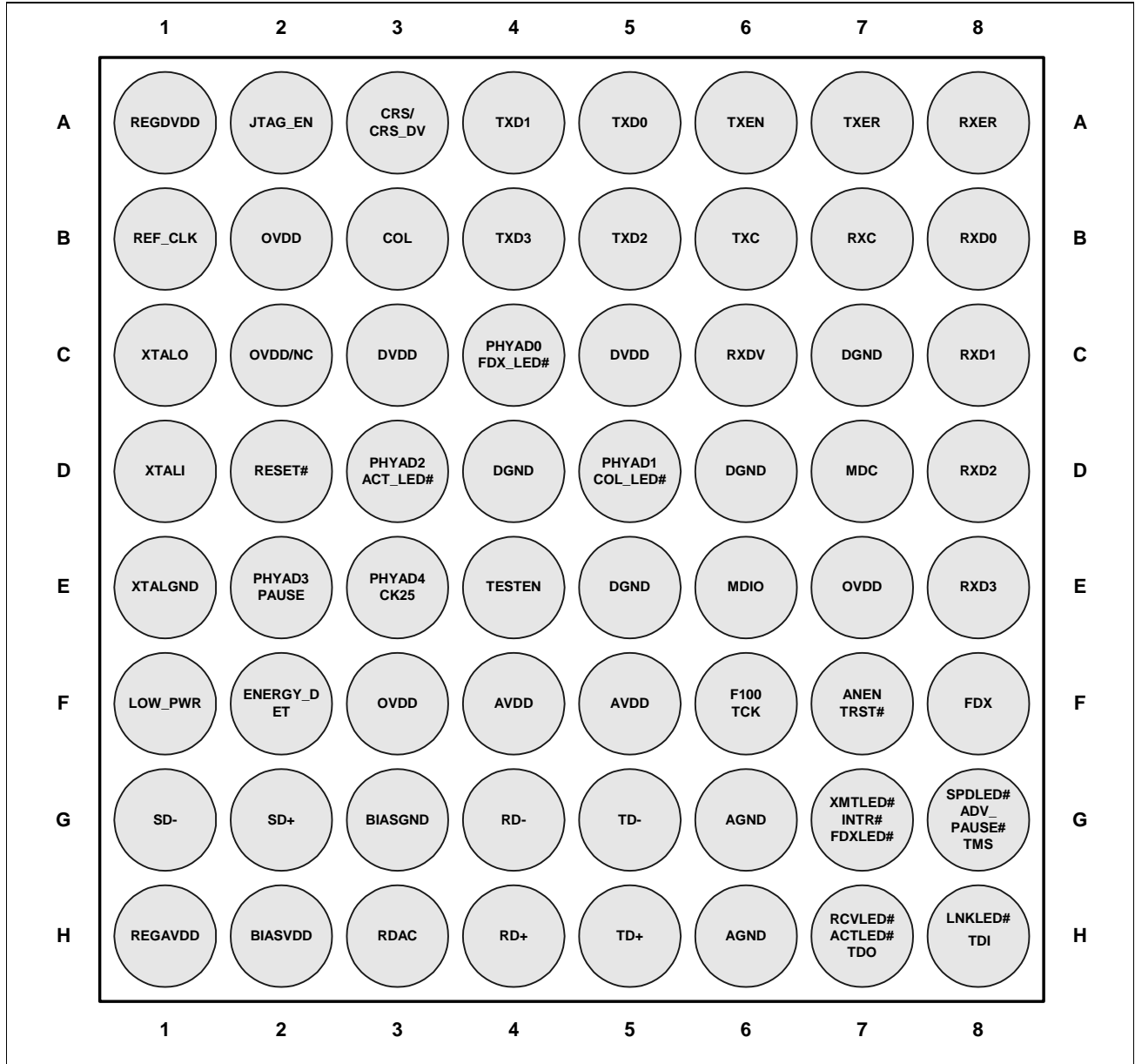


Figure 1: BCM5220KPB Ballout Diagram

Figure 2 below provides the pin diagram for the BCM5220KPT.

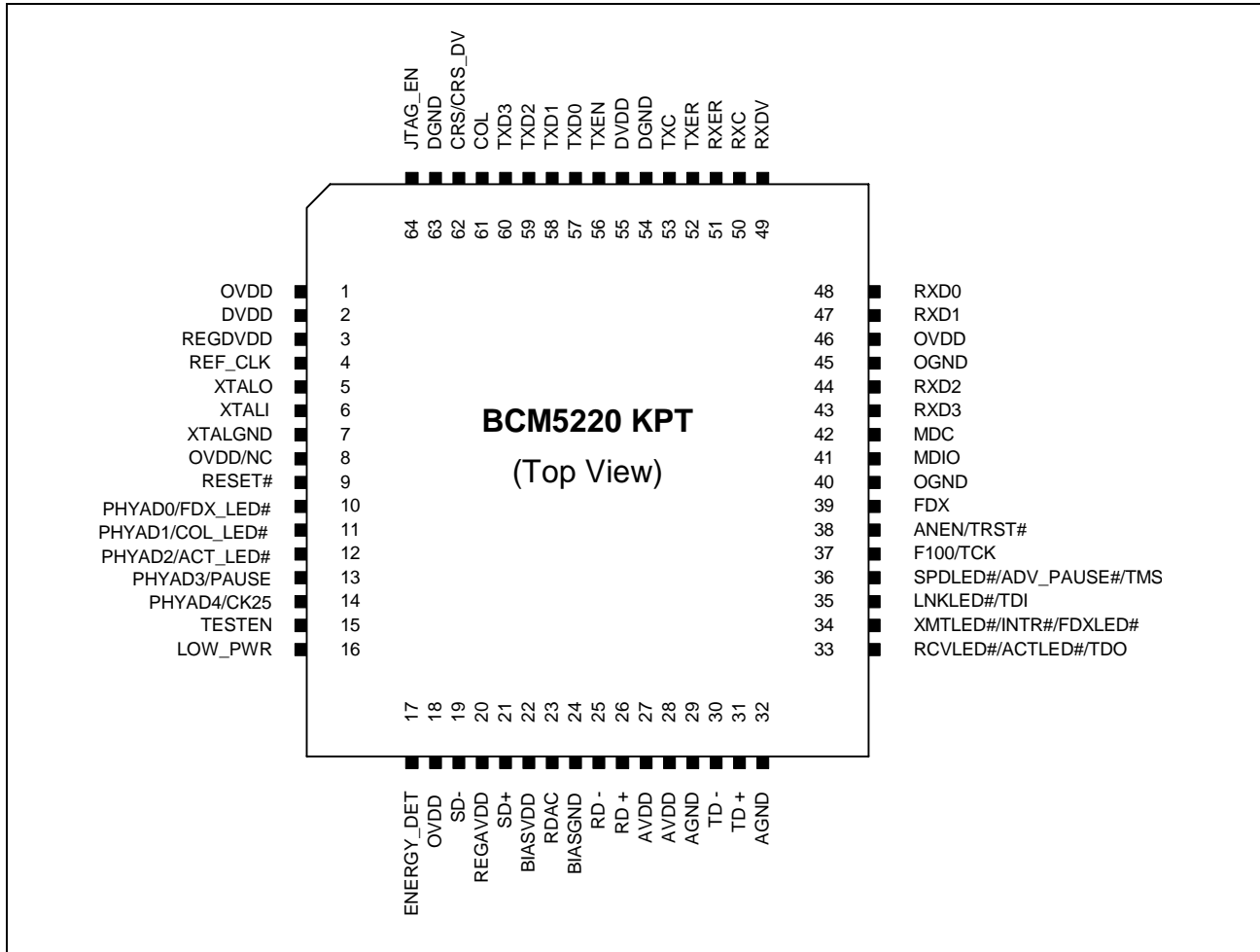


Figure 2: BCM5220KPT Pin Diagram

Section 4: Operational Description

RESET

There are two ways to reset the BCM5220. A hardware reset pin is provided that resets all internal nodes in the chip to a known state. Reset# pin must be held low when powering the BCM5220 to get this chip into normal mode. If the BCM5220 is not provided a power-on reset, it is possible for the chip to power up in a low power mode. To exit this low power mode, reset# pin must be held low for at least 20 μ s. Hardware reset should always be applied to the BCM5220 after power-up.

The BCM5220 also has a software reset capability. To perform software reset, a 1 must be written to bit 15 of the MII Control register. This bit is self-clearing, meaning that a second write operation is not necessary to end the reset. There is no effect if a 0 is written to the MII Control register reset bit.

The BCM5220 clock input can be driven two ways: internal crystal oscillator or external oscillator. To take advantage of the internal oscillator, attach a 25-MHz crystal between the XTALI and XTALO pins. Connect 27 pF capacitors from each pin to ground. Alternatively, a 50% duty cycle 25-MHz clock can be directly applied to the XTALI pin. In this case, the XTALO output must be left unconnected. No capacitors are used.

ISOLATE MODE

When the BCM5220 is put into isolate mode, all MII inputs (TXD[3:0], TXEN, and TXER) are ignored, and all MII outputs (TXC, COL, CRS, RXC, RXDV, RXER, and RXD[3:0]) are set to high impedance. Only the MII management pins (MDC, MDIO) operate normally. Upon resetting the chip, the isolate mode is off. Writing a 1 to bit 10 of the MII Control register puts the transceiver into isolate mode. Writing a 0 to the same bit removes it from isolate mode.

LOOPBACK MODE

Loopback mode allows in-circuit testing of the BCM5220 chip. All packets sent in through the TXD pins are looped-back internally to the RXD pins, and are not sent out to the cable. The loopback mode is enabled by writing a 1 to bit 14 of the MII Control register. To resume normal operation, bit 14 of the MII Control register must be 0.

Incoming packets on the cable are ignored in loopback mode. Because of this, the COL pin is normally not activated during loopback mode. To test that the COL pin is actually working, the BCM5220 can be placed into collision test mode. This mode is enabled by writing a 1 to bit 7 of the MII Control register. Asserting TXEN causes the COL output to go high, and deasserting TXEN causes the COL output to go low.

While in loopback mode, several function bypass modes are also available that can provide a number of different combinations of feedback paths during loopback testing. These bypass modes include bypass scrambler, bypass MLT3 encoder and bypass 4B5B encoder. All bypass modes can be accessed by writing bits of the Auxiliary Control register (10h).

FULL-DUPLEX MODE

The BCM5220 supports full-duplex operation. While in full-duplex mode, a transceiver can simultaneously transmit and receive packets on the cable. The COL signal is never activated when in full-duplex mode. The CRS output is asserted only during receive packets, not transmit packets.

By default, the BCM5220 powers up in half-duplex mode. When auto-negotiation is disabled, full-duplex operation can be enabled either by FDX pin control or by an MII register bit (register 0, bit 8).

When auto-negotiation is enabled in DTE mode, full-duplex capability is advertised by default, but can be overridden by a write to the Auto-Negotiation Advertisement register (04h).

One of the LED outputs can be modified to signal full-duplex versus half-duplex operation. This capability is enabled by setting MII register 1Ah, bit 15. In this mode, XMTLED# becomes FDXLED#, where a 1 output indicates half-duplex and a 0 output indicates full-duplex. This value is the inverse of MII register 18h, bit 0. When the FDXLED mode is activated, the RCVLED# becomes ACTLED#.

100BASE-FX MODE

For 100BASE-FX mode, the BCM5220 transceiver interfaces with an external 100BASE-FX fiber-optic driver and receiver instead of the magnetics module used with twisted-pair cable. The differential transmit and receive data pairs operate at PECL voltage levels instead of those required for twisted-pair transmission. The data stream is encoded using two-level NRZI instead of three-level MLT3. Since scrambling is not used in 100BASE-FX operation, the stream cipher function is bypassed.

The external fiber-optic receiver detects signal status and passes it into the BCM5220 through the SD± pins. The SD± pins select the 100BASE-FX mode.

10BASE-T MODE

The same magnetics module used in 100BASE-TX mode can be used to interface to the twisted-pair cable when operating in 10BASE-T mode. The data is two-level Manchester encoded instead of three-level MLT3, and no scrambling/descrambling or 4B5B coding is performed. Data and clock rates are decreased by a factor of 10, with the MII interface signals operating at 2.5 MHz.

10BASE-T SERIAL MODE

The BCM5220 supports 10BASE-T serial mode, also known as the 7-wire interface. In this mode, 10BASE-T transmit and receive packets appear at the MII in serial fashion, at a rate of 10 MHz. Receive packet data is output on RXD (0) synchronously with RXC. Transmit packet data must be input on TXD (0) synchronously with TXC. Both clocks toggle at 10 MHz.

The 10BASE-T serial mode is enabled by writing a 1 to bit 1 of the Auxiliary Multiple-PHY register (1Eh). This mode is not available in 100BASE-X modes. The following table shows the MII pins used in this mode and their direction of operation.

Table 4: 10BASE-T Serial Mode (7-Wire) Signals

5220 KPT	Pin Label	Type	Description
57	TXD (0)	I	Serial Transmit Data
53	TXC	O	Transmit Data Clock (10 MHz)
56	TXEN	I	Transmit Enable
48	RXD (0)	O	Serial Receive Data
50	RXC	O	Receive Data Clock (10 MHz)
62	CRS	O	Carrier Sense
61	COL/RXEN	O	Collision Detect

SPECIAL LED MODES

Traffic Meter Mode

The blink rate of XMTLED# and RCVLED# is decreased dramatically to better show the volume of traffic. Lower traffic levels make the corresponding LED appear dimmer than higher traffic levels. This mode is activated by writing a 1 to bit 6 of the Aux Mode 2 register (1Bh).

Force LEDs On

The SPDLED#, LNKLED#, XMTLED#, RCVLED#, COL_LED#, ACT_LED#, and FDX_LED# outputs can be forced on (0 value) by writing a 01 to bit 5 and 4 of shadow register 1Ah.

Disable LEDs

The SPDLED#, LNKLED#, XMTLED#, RCVLED#, COL_LED#, ACT_LED#, and FDX_LED# outputs can be forced off (1 value) by writing a 10 to bit 5 and 4 of shadow register 1Ah.

Separate 100BASE-TX and 10-BASE-T Link

When bit 12 of register 1Dh is set to 1, LNKLED# indicates the link at 100BASE-TX and SPDLED# indicates the link at 10BASE-T.

INTERRUPT MODE

The BCM5220 can be programmed to provide an interrupt output. Three conditions can cause an interrupt to be generated: changes in the duplex mode, changes in the speed of operation or changes in the link status. The interrupt feature is disabled by default. When the interrupt capability is enabled by setting MII register 1Ah, bit 14, the XMTLED# pin becomes the INTR# pin and the RCVLED# pin becomes an activity pin named ACTLED#. The INTR# pin is open-drain and can be wire-ORed with INTR# pins of other chips on a board. The status of each interrupt source is reflected in register 1Ah, bits 1, 2 and 3. If any type of interrupt occurs, the Interrupt Status bit, register 1Ah, bit 0, is set.

The Interrupt register (1Ah) also contains several bits to control different facets of the interrupt function. If the interrupt enable bit is set to 0, no status bits are set and no interrupts are generated. If the interrupt enable bit is set to 1, the following conditions apply:

- If mask status bits (bits 9,10,11) are set to 0 and the interrupt mask (bit 8) is set to 0, status bits and interrupts are available.
- If mask status bits (bits 9,10,11) are set to 0 and the interrupt mask (bit 8) is set to 1, status bits are set but no interrupts generated.
- If any mask status bit is set to 1 and the interrupt mask is set to 0, that status bit is not set and no interrupt of that type is generated.
- If any mask status bit is set to 1 and the interrupt mask is set to 1, that status bit is not set and no interrupt of any kind is generated.

ENERGY DETECTION

An on-chip energy detection circuit can determine when a link partner is connected to the end of the transmission media. The circuit monitors the receive inputs for any type of energy, including 10BASE-T, 100BASE-TX or 100BASE-FX packets, and 10BASE-T or auto-negotiation link pulses. When energy is detected on the receive inputs for longer than 1.3 ms, the ENERGYDET output is asserted. If all traces of energy disappear for longer than 1.3s, it is assumed that the link partner has disconnected, and the ENERGYDET output is deasserted. The energy detection circuit is operational in both full power and some of the low power modes.

POWER SAVING MODES

Several power saving modes are implemented in the BCM5220, which target PCMCIA and CardBus applications. Table 5 on page 17 shows low power modes available in the BCM5220. Low power modes can be achieved either by hardware pin or MII register programming. The table shows both hardware pin and software bits that determine the low power modes and whether the BCM5220 keeps the clocks and the energy detect circuitry active. The BCM5220 requires a hard reset for a minimum of 20 μ s to return to normal mode from a low power mode if the clocks are not running. Allow at least 2 ms before resuming normal operation with the BCM5220 after the device is set to run in normal mode from a low power mode. It is necessary to choose an appropriate low power mode if the energy detection function support is required while the BCM5220 is in low power mode.

Table 5: Low Power Modes

<i>Low_PWR</i>	<i>Reset#</i>	<i>Force IDDQ</i>	<i>Low_pwr Mode</i>	<i>Enable Clock</i>	<i>Clocks</i>	<i>Energy Detect</i>
X	0	X	X	X	OFF	OFF
0	1	0	0	X	RUN	ON
X	X	1	X	X	OFF	OFF
1	1	0	0	0	OFF	ON
1	1	0	0	1	RUN	ON
0	1	0	1	0	OFF	ON
0	1	0	1	1	RUN	ON

LOW_PWR: Pin-16 (BCM5220KPT), Pin-F1 (BCM5220KPB)

RESET#: Pin-9 (BCM5220KPT), Pin-D2 (BCM5220KPB)

FORCE IDDQ: Bit-0 of Shadow register 1Ah

LOW PWR MODE: Bit-1 of Shadow register 1Ah

ENABLE CLOCK: Bit-2 of Shadow register 1Ah

X = 1/0 or Don't Care

AUTO POWER-DOWN MODE

In addition to various low power modes shown in Table 5, the BCM5220 also supports a special low power mode called Auto Power Down Mode. Auto Power Down mode is enabled by setting bit 5 of Shadow register 1Bh. When in this mode, the BCM5220 automatically enters the low power mode if the energy from the Link partner is lost. Similarly, the next time energy is detected, the chip resumes full power mode. When the BCM5220 is in this low power mode, it wakes up after 2.5/5.0s (approximately), as determined by bit 4 of Shadow register 1Bh, and send link pulse while monitoring energy from the Link partner. If energy is detected, the BCM5220 enters full power mode and establishes link with the Link partner. Otherwise, the wake-up mode continues for a duration of 40-600 ms (approximately) as determined by bits [3:0] of Shadow register 1Bh before going to low power mode. See the Shadow register, Table 8 on page 23, for a details of various bits.

Section 5: Register Summary

MEDIA INDEPENDENT INTERFACE (MII) MANAGEMENT INTERFACE: REGISTER PROGRAMMING

The BCM5220 fully complies with the IEEE 802.3u Media Independent Interface (MII) specification. The MII management interface registers are serially written to and read from using the MDIO and MDC pins. A single clock waveform must be provided to the BCM5220 at a rate of 0–25MHz through the MDC pin. The serial data is communicated on the MDIO pin. Every MDIO bit must have the same period as the MDC clock. The MDIO bits are latched on the rising edge of the MDC clock.

See Table 6 for the fields in every MII instruction's read or write packet frame.

Table 6: MII Management Frame Format

<i>Operation</i>	<i>PRE</i>	<i>ST</i>	<i>OP</i>	<i>PHYAD</i>	<i>REGAD</i>	<i>TA</i>	<i>DATA</i>	<i>Idle</i>	<i>Direction</i>
READ	1 ... 1	01	10	AAAAA	RRRRR	ZZ Z0	Z ... Z D ... D	Z Z	Driven to BCM5220 Driven by BCM5220
WRITE	1 ... 1	01	01	AAAAA	RRRRR	10	D ... D	Z	Driven to BCM5220

Preamble (PRE)

32 consecutive 1 bits must be sent through the MDIO pin to the BCM5220 to signal the beginning of an MII instruction. Fewer than 32 1 bits causes the remainder of the instruction to be ignored, unless the Preamble Suppression mode is enabled (register 01, bit 6).

Start of Frame (ST)

A 01 pattern indicates that the start of the instruction follows.

Operation Code (OP)

A read instruction is indicated by 10, while a write instruction is indicated by 01.

PHY Address (PHYAD)

A 5-bit PHY address follows next, with the MSB transmitted first. The PHY address allows a single MDIO bus to access multiple transceivers. The BCM5220 supports the full 32-PHY address space.

Register Address (REGAD)

A 5-bit register address follows, with the MSB transmitted first. The register map of the BCM5220, containing register addresses and bit definitions, are provided on the following pages.



Turnaround (TA)

The next two bit times are used to avoid contention on the MDIO pin when a read operation is performed. For a write operation, 10 must be sent to the chip during these two bit times. For a read operation, the MDIO pin must be placed into high-impedance during these two bit times. The chip drives the MDIO pin to 0 during the second bit time.

Data

The last 16 bits of the frame are the actual data bits. For a write operation, these bits are sent to the BCM5220. For a read operation, these bits are driven by the BCM5220. In either case, the MSB is transmitted first.

When writing to the BCM5220, the data field bits must be stable 10 ns before the rising-edge of MDC, and must be held valid for 10 ns after the rising edge of MDC. When reading from the BCM5220, the data field bits are valid after the rising edge of MDC until the next rising edge of MDC.

Idle

A high-impedance state of the MDIO line. All drivers are disabled and the PHY's pull-up resistor pulls the line high. At least one or more clocked idle states are required between frames. Following are two examples of MII write and read instructions.

To put a chip with PHY address 00001 into loopback mode, the following MII write instruction must be issued:

```
1111 1111 1111 1111 1111 1111 1111 1111 0101 00001 00000 10 0100 0000 0000 0000 1...
```

To determine whether a PHY is in the link pass state, the following MII read instruction must be issued:

```
1111 1111 1111 1111 1111 1111 1111 1111 0110 00001 00001 ZZ ZZZZ ZZZZ ZZZZ ZZZZ 1...
```

For the MII read operation, the BCM5220 drives the MDIO line during the TA and Data fields (the last 17 bit times). A final 65th clock pulse must be sent to close the transaction and cause a write operation.

MII REGISTER MAP SUMMARY

Table 7 contains the MII register summary for the BCM5220. The register addresses are specified in hex form, and the name of register bits have been abbreviated. When writing to any register, preserve existing values of the reserved bits by completing a "Read/Modify Write." Ignore reserved bits when reading registers. Never write to an undefined register. The reset values of the registers are shown in the INIT column. Some of these values could be different depending on how the device is configured and also depending on the device revision value.

Table 7: MII Register Map Summary

ADDR	NAME	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	INIT	
00h	CONTROL	Soft Reset	Loopback	Force100	AutoNeg Enable	Power Down	Isolate	Restart AutoNeg	Full Duplex	Collision Test	Reserved							3000h	
01h	STATUS	T4 Capable	TX FDX Capable	TX Capable	BT FDX Capable	10BT Capable	Reserved	Reserved	Reserved	MF pream suppress	AutoNeg comp	Remote Fault	AutoNeg Capable	Link Status	Jabber Detect	Exit Reg Capable	7809h		
02h	PHYID HIGH	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0040h	
03h	PHYID LOW	0	1	1	0	0	0	0	1	1	Mode#	1	0	Revision #	0	0	0	61E0h	
04h	AUTONEG ADVERTISE	Next Page	Reserved	Remote Fault	Reserved Tech	Reserved Tech	Pause	Adv T4	Adv TX FDX	Adv TX	Adv BT FDX	Adv BT	0	Advertised Selector Field [4:0]	0	0	1	01E1h	
05h	LINK PARTNER ABILITY	LP Next Page	LP Acknowledge	LP Rem Fault	Reserved Tech	Reserved Tech	LP Pause	LP T4	LP TX FDX	LP TX	LP BT FDX	LP BT	Link Partner Selector Field [4:0]					0000h	
06h	AUTONEG EXPANSION	Reserved																0004h	
07h	NEXT PAGE	Next Page	Reserved	Message Page	Acknowledge2	Acknowledge2	Toggle	Message/Unformatted Code Field											2001h
08h	LP NEXT PAGE	Next Page	Reserved	Message Page	Acknowledge2	Acknowledge2	Toggle	Message/Unformatted Code Field											0000h
10h	100BASE-X AUX CONTROL	Reserved	Reserved	Trans Disable	Reserved	Reserved	Bypass 4B5B Enc/Dec	Bypass Scram/Descram	Bypass NRZI Enc/Dec	Bypass Rcv Sym Align	BASEline Wander Disable	FEF Enable	Reserved				0000h		
11h	100BASE-X AUX STATUS	Reserved	Reserved	FXMode	Locked	Current 100Link Status	Current Remote Fault	Bad ESD Detected	RCV Error Detected	LockError Detected	MLT3 Error Detected					0000h			
12h	100BASE-X RCV ERROR COUNTER	Receive Error Counter [15:0]																0000h	
13h	100BASE-X FALSE CARRIER COUNTER	Reserved																0000h	
		False Carrier Sense Counter [7:0]																0000h	

Table 7: MII Register Map Summary (Cont.)

ADDR	NAME	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	INIT	
14h	100BASE-X DISCONNECT COUNTER	Reserved															0	0200h	
15h	RESERVED	Reserved																0300h	
16h	RESERVED	Reserved																0000h	
17h	PTEST	Reserved																0000h	
18h	AUXILIARY CONTROL/ STATUS	Jabber Disable	Force Link	Reserved	Reserved	AutoNeg Pause	AutoNeg HCD	AutoNeg HCD	AutoNeg HCD	LP Remote Fault	LSQ	Edge Rate [1:0]	LP Page Rcvd	LP AutoNeg Able	SP100 Indicator	AutoNeg Enable Indicator	Force 100 Indicator	SP100 Indicator	FDX Indicator
19h	AUXILIARY STATUS SUMMARY	AutoNeg Complete	AutoNeg CompleteAck	AutoNeg Ack Detect	AutoNeg Ability Detect	AutoNeg Pause	AutoNeg HCD	AutoNeg HCD	AutoNeg HCD	LP Remote Fault	LP Remote Fault	LP Page Rcvd	LP Page Rcvd	LP AutoNeg Able	SP100 Indicator	SP100 Indicator	Link Status	Link Status	Jabber Detect
1Ah	INTERRUPT	FDX LED Enable	INTR Enable	Reserved	Reserved	FDX Mask	SPD Mask	SPD Mask	INTR Mask	Reserved	Reserved	Reserved	Reserved	FDX Change	SPD Change	Link Change	INTR Status	INTR Status	9F0xh
1Bh	AUXILIARY MODE2	Reserved	Reserved	Reserved	Reserved	10BT Dribble Correct	Token Ring Mode	HSTR FIFO Enable	Reserved	Block 10BT Echo Mode	Traffic Meter LED Mode	Activity LED Force On	Reserved	Reserved	SQE Disable	Activity/Link LED Enable	Qual Parallel Detect Mode	Reserved	008Ah
1Ch	10BASE-T AUX. ERROR & GENERAL STATUS	Reserved	Reserved	Reserved	Reserved	Reserved	Manchester Code Err (BT)	Reserved	Reserved	Reserved	0	1	Reserved	Reserved	Force 100 Indicator	SP100 Indicator	FDX Indicator	FDX Indicator	002xh
1Dh	AUXILIARY MODE	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Block TXEN Mode	Reserved	x000h
1Eh	AUXILIARY MULTI-PHY	HCD TX FDX	HC T4	HCD TX	HCD 10BT FDX	HCD 10BT	Reserved	Restart AutoNeg	AutoNeg Complete	Reserved	ACK Detect	ACK Detect	Ability Detect	Super Isolate	Reserved	Reserved	10BT Serial Mode	RXER Code Mode	0000h
1Fh	BROADCOM TEST	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Shadow Register Enable	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	000Bh

Table 8: MII Shadow Register Map Summary

ADDR NAME	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	INIT
18h RESERVED	Reserved																003Ah
1Ah AUXILIARY MODE 4	Reserved										LED Force [1:0]		Reserved	Enable Clocks During Low Pwr Mode	Force Low Pwr Mode	Force IDIQ Mode	3000h
1Bh AUXILIARY STATUS 2	MLT3 Detect	Reserved							APD Enable		APD Sleep Timer		APD Wake-up Timer [3:0]				0001h
1Ch AUXILIARY STATUS 3	Reserved							FLP Detect	NLP Detect	Link Break Timer Expire	LinkFail Timer Expire		FIFO Consumption[3:0]				0000h
1Dh AUXILIARY MODE 3	Reserved												FIFO Size Select [3:0]				0C04h
1Eh AUXILIARY STATUS 4	Packet Length Counter [15:0]																0000h

MII CONTROL REGISTER

The MII control register bit descriptions are shown in Table 9.

Table 9: MII Control Register (Address 00000b, 0d, 00h)

Bit	Name	R/W	Description	Default
15	Soft Reset	R/W (SC)	1 = PHY reset 0 = Normal operation	0
14	Loopback	R/W	1 = Loopback mode 0 = Normal operation	0
13	Forced Speed Selection	R/W	1 = 100 Mbps 0 = 10 Mbps	1
12	Auto-Negotiation Enable	R/W	1 = Auto-negotiation enable 0 = Auto-negotiation disable	1
11	Power Down	RO	0 = Normal operation	0
10	Reserved ^a	R/W	-	0
9	Restart Auto-Negotiation	R/W (SC)	1 = Restart Auto-negotiation process 0 = Normal operation	0
8	Duplex Mode	R/W	1 = Full-duplex 0 = Half-duplex	0
7	Reserved ^a	-	-	0
6:0	Reserved ^a	-	-	0

Note: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = latched low, LH = latched high (LL and LH are cleared after read operation)

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Reset

To reset the BCM5220 by software control, a 1 must be written to bit 15 of the Control register using an MII write operation. The bit clears itself after the reset process is complete, and need not be cleared using a second MII write. Writes to other Control register bits have no effect until the reset process is completed, which requires approximately 1 microsecond. Writing a 0 to this bit has no effect. Since this bit is self-clearing, after a few cycles from a write operation, it returns a 0 when read.

Loopback

The BCM5220 may be placed into loopback mode by writing a 1 to bit 14 of the Control register. Clear the loopback mode by writing a 0 to bit 14 of the control register, or by resetting the chip. When this bit is read, it returns a 1 when the chip is in loopback mode, otherwise it returns a 0.

Forced Speed Selection

If auto-negotiation is enabled (both auto-negotiation pin and bit are enabled) or disabled by hardware control (auto-negotiation pin is pulled-low), this bit has no effect on the speed selection. However, if auto-negotiation is disabled by software control, the operating speed of the BCM5220 can be forced by writing the appropriate value to bit 13 of the Control register. Writing a 1 to this bit forces 100BASE-X operation, while writing a 0 forces 10BASE-T operation. When this bit is read, it returns the value of the software-controlled forced speed selection only. To read the overall state of forced speed selection, including both hardware and software control, use bit 2 of the Auxiliary Control register (18h).



Auto-Negotiation Enable

Auto-negotiation can be disabled by one of two methods: hardware or software control. If the ANEN input pin is driven to a logic 0, auto-negotiation is disabled by hardware control. If bit 12 of the Control register is written with a value of 0, auto-negotiation is disabled by software control. When auto-negotiation is disabled in this manner, writing a 1 to the same bit of the Control register or resetting the chip re-enables auto-negotiation. Writing to this bit has no effect when auto-negotiation has been disabled by hardware control. When read, this bit returns the value most recently written to this location, or 1 if it has not been written since the last chip reset.

Power Down

The power modes of the BCM5220 are not accessible by this MII register bit. Use LOWPWR pin control instead.

Isolate

The PHY can be isolated from its Media Independent Interface by writing a 1 to bit 10 of the Control register. All MII outputs are tri-stated and all MII inputs are ignored. Because the MII management interface is still active, the isolate mode can be cleared by writing a 0 to bit 10 of the control register, or by resetting the chip. When this bit is read, it returns a 1 when the chip is in isolate mode; otherwise it returns a 0.

Restart Auto-Negotiation

Bit 9 of the Control register is a self-clearing bit that allows the auto-negotiation process to be restarted, regardless of the current status of the auto-negotiation state machine. For this bit to have an effect, auto-negotiation must be enabled. Writing a 1 to this bit restarts the auto-negotiation, while writing a 0 to this bit has no effect. Because the bit is self-clearing after only a few cycles, it always returns a 0 when read. The operation of this bit is identical to bit 8 of the Auxiliary Multiple PHY register (1Eh).

Duplex Mode

By default, the BCM5220 powers up in half-duplex mode. The chip can be forced into full-duplex mode by writing a 1 to bit 8 of the Control register while auto-negotiation is disabled. Half-duplex mode can be resumed by writing a 0 to bit 8 of the Control register, or by resetting the chip.

Collision Test

Test the COL pin by activating the collision test mode. While in this mode, asserting TXEN causes the COL output to go high within 512 bit times. Deasserting TXEN causes the COL output to go low within 4 bit times. Writing a 1 to bit 7 of the Control register enables the collision test mode. Writing a 0 to this bit or resetting the chip disables the collision test mode. When this bit is read, it returns a 1 when the collision test mode has been enabled; otherwise it returns a 0. This bit should only be set while in loopback test mode.

Reserved Bits

All reserved MII register bits must be written as 0 at all times. Ignore the BCM5220 output when these bits are read.



MII STATUS REGISTER

The MII status register bit descriptions are shown in Table 10.

Table 10: MII Status Register (Address 00001B, 01d, 01h)

Bit	Name	R/W	Description	Default
15	100BASE-T4 Capability	RO	0 = Not 100BASE-T4 capable	0
14	100BASE-TX FDX Capability	RO	1 = 100BASE-TX full-duplex capable	1
13	100BASE-TX Capability	RO	1 = 100BASE-TX half-duplex capable	1
12	10BASE-T FDX Capability	RO	1 = 10BASE-T full-duplex capable	1
11	10BASE-T Capability	RO	1 = 10BASE-T half-duplex capable	1
10:7	Reserved ^a	RO	Ignore when read Ignore when read	0
6	MF Preamble Suppression	R/W	1 = Preamble may be suppressed 0 = Preamble always required	0
5	Auto-Negotiation Complete	RO	1 = Auto-negotiation process completed 0 = Auto-negotiation process not completed	0
4	Remote Fault	RO	1 = Far-end fault condition detected 0 = No far-end fault condition detected	0
3	Auto-Negotiation Capability	RO	1 = Auto-negotiation capable 0 = Not Auto-negotiation capable	1
2	Link Status	RO LL	1 = Link is up (link pass state) 0 = Link is down (link fail state)	0
1	Jabber Detect	RO LL	1 = Jabber condition detected 0 = No jabber condition detected	0
0	Extended Capability	RO	1 = Extended register capable	1

Note: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = latched low, LH = latched high (LL and LH are cleared after read operation)

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

100BASE-T4 Capability

The BCM5220 is not capable of 100BASE-T4 operation, and returns a 0 when bit 15 of the status register is read.

100BASE-X Full-Duplex Capability

The BCM5220 is capable of 100BASE-X full-duplex operation, and returns a 1 when bit 14 of the Status register is read.

100BASE-X Half-Duplex Capability

The BCM5220 is capable of 100BASE-X half-duplex operation, and returns a 1 when bit 13 of the Status register is read.

10BASE-T Full-Duplex Capability

The BCM5220 is capable of 10BASE-T full-duplex operation, and returns a 1 when bit 12 of the Status register is read.



10BASE-T Half-Duplex Capability

The BCM5220 is capable of 10BASE-T half-duplex operation, and returns a 1 when bit 11 of the Status register is read.

Reserved Bits

Ignore the BCM5220 output when these bits are read.

Preamble Suppression

This bit is the only writable bit in the Status register. Setting this bit to a 1 allows subsequent MII management frames to be accepted with or without the standard preamble pattern. When preamble suppression is enabled, only 2 preamble bits are required between successive management commands, instead of the normal 32.

Auto-Negotiation Complete

Returns a 1 if auto-negotiation process has been completed and the contents of registers 4, 5, and 6 are valid.

Remote Fault

The PHY returns a 1 on bit 4 of the status register when its link partner has signalled a far-end fault condition. When a far-end fault occurs, the bit is latched at 1 and remains so until the register is read and the remote fault condition has been cleared.

Auto-Negotiation Capability

The BCM5220 is capable of performing IEEE auto-negotiation, and returns a 1 when bit 4 of the Status register is read, regardless of whether the auto-negotiation function has been disabled.

Link Status

The BCM5220 returns a 1 on bit 2 of the Status register when the link state machine is in link pass, indicating that a valid link has been established. Otherwise, it returns 0. When a link failure occurs after the link pass state has been entered, the link status bit is etched at 0 and remains so until the bit is read. After the bit is read, it becomes 1 when the link pass state is entered again.

Jabber Detect

10BASE-T operation only. The BCM5220 returns a 1 on bit 1 of the Status register if a jabber condition has been detected. After the bit is read once, or if the chip is reset, it reverts to 0.

Extended Capability

The BCM5220 supports extended capability registers, and returns a 1 when bit 0 of the Status register is read. Several extended registers have been implemented in the BCM5220, and their bit functions are defined later in this section.

PHY IDENTIFIER REGISTERS

The physical identifier registers bit descriptions are shown in Table 11.

Table 11: PHY Identifier Registers (Addresses 00010 and 00011b, 02 and 03b, 02 and 03h)

<i>Bit</i>	<i>Name</i>	<i>R/W</i>	<i>Description</i>	<i>Value</i>
15:0	MII Address 02h	RO	PHYID HIGH	0040h
15:0	MII Address 03h	RO	PHYID LOW	61E0h

Broadcom Corporation has been issued an Organizationally Unique Identifier (OUI) by the IEEE. It is a 24-bit number, 00-10-18, expressed as hex values. That number, along with the Broadcom Model Number for the BCM5220 part, 1Eh, and Broadcom Revision number, 0h for the A0 is placed into two MII registers. The translation from OUI, Model Number and Revision Number to PHY Identifier register occurs as follows:

- PHYID HIGH [15:0] = OUI[21:6]
- PHY LOW [15:0] = OUI[5:0] + MODEL[5:0] + REV[3:0]

The 2 most significant bits of the OUI are not represented (OUI[23:22]).

Table 11 shows the result of concatenating these values to form MII Identifier registers PHYID HIGH and PHYID LOW.



AUTO-NEGOTIATION ADVERTISEMENT REGISTER

Table 12: *Auto-Negotiation Advertisement Register (Address 04d, 04h)*

Bit	Name	R/W	Description	Default
15	Next Page	R/W	1 = Next page ability is enabled 0 = Next page ability is disabled	0
14	Reserved ^a	RO	Ignore when read	
13	Remote Fault	R/W	1 = Transmit remote fault	0
12:11	Reserved Technologies	RO	Ignore when read	00
10	Pause	R/W	1 = Pause operation for full-duplex	0
9	Advertise 100BASE-T4	R/W	1 = Advertise T4 capability 0 = Do not advertise T4 capability	0
8	Advertise 100BASE-X FDX	R/W	1 = Advertise 100BASE-X full-duplex 0 = Do not advertise 100BASE-X full-duplex	1
7	Advertise 100BASE-X	R/W	1 = Advertise 100BASE-X	1
6	Advertise 10BASE-T FDX	R/W	1 = Advertise 10BASE-T full-duplex 0 = Do not advertise 10BASE-T full-duplex	1
5	Advertise 10BASE-T	R/W	1 = Advertise 10BASE-T	1
4:0	Advertise Selector Field	R/W	Indicates 802.3	00001

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Next Page

The BCM5220 supports the next page function.

Reserved Bits

Ignore output when read.

Remote Fault

Writing a 1 to bit 13 of the Advertisement register causes a remote fault indicator to be sent to the link partner during auto-negotiation. Writing a 0 to this bit or resetting the chip clears the remote fault transmission bit. This bit returns the value last written to it, or else 0 if no write has been completed since the last chip reset.

Reserved Technologies Bits

Ignore output when read.

Pause

Pause operation for full-duplex links. The use of this bit is independent of the negotiated data rate, medium, or link technology. The setting of this bit indicates the availability of additional DTE capability when full-duplex operation is in use. This bit is used by one MAC to communicate pause capability to its link partner and has no effect on PHY operation.

Advertisement Bits

Use bits 9:5 of the Advertisement register to customize the ability information transmitted to the link partner. The default value for each bit reflects the abilities of the BCM5220. By writing a 1 to any of the bits, the corresponding ability can be transmitted to the link partner. Writing a 0 to any bit causes the corresponding ability to be suppressed from transmission. Resetting the chip restores the default bit values. Reading the register returns the values last written to the corresponding bits, or else the default values if no write has been completed since the last chip reset.

Selector Field

Bits 4:0 of the Advertisement register contain the value 00001, indicating that the chip belongs to the 802.3 class of PHY transceivers.

AUTO-NEGOTIATION LINK PARTNER (LP) ABILITY REGISTER

Table 13: *Auto-Negotiation Link Partner Ability Register (Address 05d, 05h)*

Bit	Name	R/W	Description	Default
15	LP Next Page	RO	Link partner next page bit	0
14	LP Acknowledge	RO	Link partner acknowledge bit	0
13	LP Remote Fault	RO	Link partner remote fault indicator	0
12:11	Reserved Technologies	RO	Ignore when read	000
10	LP Advertise Pause	RO	Link partner has pause capability	0
9	LP Advertise 100BASE-T4	RO	Link partner has 100BASE-T4 capability	0
8	LP Advertise 100BASE-X FDX	RO	Link partner has 100BASE-X FDX capability	0
7	LP Advertise 100BASE-X	RO	Link partner has 100BASE-X capability	0
6	LP Advertise 10BASE-T FDX	RO	Link partner has 10BASE-T FDX capability	0
5	LP Advertise 10BASE-T	RO	Link partner has 10BASE-T capability	0
4:0	Link Partner Selector Field	RO	Link partner selector field	00000

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

The values contained in the Auto-Negotiation Link Partner Ability register are only guaranteed to be valid after auto-negotiation has successfully completed, as indicated by bit 5 of the MII Status register.

LP Next Page

Bit 15 of the Link Partner Ability register returns a value of 1 when the link partner implements the next page function and has next page information that it wants to transmit. The BCM5220 does not implement the next page function, and thus ignores the next page bit, except to copy it to this register.

LP Acknowledge

Bit 14 of the Link Partner Ability register is used by auto-negotiation to indicate that a device has successfully received its link partner's link code word.

LP Remote Fault

Bit 13 of the Link Partner Ability register returns a value of 1 when the link partner signals that a remote fault has occurred. The BCM5220 simply copies the value to this register and does not act upon it.

Reserved Bits

Ignore when read.

LP Advertise Pause

Indicates that the Link Partner Pause bit is set.

LP Advertise Bits

Bits 9:5 of the Link Partner Ability register reflect the abilities of the link partner. A 1 on any of these bits indicates that the link partner is capable of performing the corresponding mode of operation. Bits 9:5 are cleared any time auto-negotiation is restarted or the BCM5220 is reset.

LP Selector Field

Bits 4:0 of the Link Partner Ability register reflect the value of the link partner's selector field. These bits are cleared any time auto-negotiation is restarted or the chip is reset.

AUTO-NEGOTIATION EXPANSION REGISTER

Table 14 shows the Auto-Negotiation Expansion Register bit descriptions.

Table 14: Auto-Negotiation Expansion Register (Address 00110b, 6d, 06h)

Bit	Name	R/W	Description	Default
15:5	Reserved ^a	RO	Ignore when read	
4	Parallel Detection Fault	RO LH	1 = Parallel detection fault 0 = No parallel detection fault	0
3	Link Partner Next Page Able	RO	1 = Link partner has next page capability 0 = Link partner does not have next page	0
2	Next Page Able	RO	1 = BCM5220 does have next page capability	1
1	Page Received	RO	1 = New page has been received 0 = New page has not been received	0
0	Link Partner Auto-Negotiation Able	RO LH	1 = Link partner has auto-negotiation capability 0 = Link partner does not have auto-negotiation	0

Note: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = latched low, LH = latched high (LL and LH are cleared after read operation)

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Reserved Bits

Ignore when read.

Parallel Detection Fault

Bit 4 of the Auto-Negotiation Expansion register is a read-only bit that gets latched high when a parallel detection fault occurs in the auto-negotiation state machine. For further details, refer to the IEEE standard. The bit is reset to 0 after the register is read, or when the chip is reset.

Link Partner Next Page Able

Bit 3 of the Auto-Negotiation Expansion register returns a 1 when the link partner has next page capabilities. It has the same value as bit 15 of the Link Partner Ability register.

Next Page Able

The BCM5220 returns 1 when bit 2 of the Auto-Negotiation Expansion register is read, indicating that it has next page capabilities.

Page Received

Bit 1 of the Auto-Negotiation Expansion register is latched high when a new link code word is received from the link partner, checked, and acknowledged. It remains high until the register is read, or until the chip is reset.

Link Partner Auto-Negotiation Able

Bit 0 of the Auto-Negotiation Expansion register returns a 1 when the link partner is known to have auto-negotiation capability. Before any auto-negotiation information is exchanged, or if the link partner does not comply with IEEE auto-negotiation, the bit returns a value of 0.

AUTO-NEGOTIATION NEXT PAGE REGISTER

Table 15: *Next Page Transmit Register (Address 07d, 07h)*

Bit	Name	R/W	Description	Default
15	Next Page	R/W	1 = Additional next page(s) will follow 0 = Last page	0
14	Reserved ^a	R/W	Ignore when read	0
13	Message Page	R/W	1= Message page 0 = Unformatted page	1
12	Acknowledge 2	R/W	1 = Will comply with message 0 = Cannot comply with message	0
11	Toggle	RO	1 = Previous value of the transmitted link code word equalled logic zero 0 = Previous value of the transmitted link code word equalled logic one	0
10:0	Message/Unformatted Code Field	R/W		1

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Next Page

Indicates whether this is the last next page to be transmitted.

Message Page

Differentiates a Message Page from an Unformatted Page.

Acknowledge 2

Indicates that a device has the ability to comply with the message.

Toggle

Used by the Arbitration function to ensure synchronization with the link partner during next page exchange.

Message Code Field

An 11-bit-wide field encoding 2048 possible messages.

Unformatted Code Field

An 11-bit-wide field, which may contain an arbitrary value.

AUTO-NEGOTIATION LINK PARTNER (LP) NEXT PAGE TRANSMIT REGISTER

Table 16: *Next Page Transmit Register (Address 08d, 08h)*

<i>Bit</i>	<i>Name</i>	<i>R/W</i>	<i>Description</i>	<i>Default</i>
15	Next Page	RO	1 = Additional next page(s) will follow 0 = Last page	0
14	Reserved ^a	RO	Ignore when read	0
13	Message Page	RO	1 = Message page 0 = Unformatted page	0
12	Acknowledge 2	RO	1 = Will comply with message 0 = Cannot comply with message	0
11	Toggle	RO	1 = Previous value of the transmitted link code word equalled logic zero 0 = Previous value of the transmitted link code word equalled logic one	0
10:0	Message/Unformatted Code Field	RO		0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Next Page

Indicates whether this is the last next page.

Message Page

Differentiates a Message Page from an Unformatted Page.

Acknowledge 2

Indicates that link partner has the ability to comply with the message.

Toggle

Used by the Arbitration function to ensure synchronization with the link partner during next page exchange.

Message Code Field

An 11-bit-wide field encoding 2048 possible messages.

Unformatted Code Field

An 11-bit-wide field, which may contain an arbitrary value.



100BASE-X AUXILIARY CONTROL REGISTER

Table 17: 100BASE-X Auxiliary Control Register (Address 16d, 10h)

Bit	Name	R/W	Description	Default
15:14	Reserved ^a		Write as 0, Ignore when read	0
13	Transmit Disable	R/W	1 = Transmitter disabled in PHY 0 = Normal operation	0
12	Reserved ^a	R/W	Write as 0, Ignore when read	0
11	Reserved ^a		Write as 0, Ignore when read	0
10	Reserved ^a	R/W	Write as 0, ignore when read	0
9	Bypass Scrambler/ Descrambler	R/W	1 = Scrambler and descrambler disabled 0 = Scrambler and descrambler enabled	0
8	Bypass NRZI Encoder/ Decoder	R/W	1 = NRZI encoder and decoder is disabled 0 = NRZI encoder and decoder is enabled	0
7	Bypass Receive Symbol Alignment	R/W	1 = 5B receive symbols not aligned 0 = Receive symbols aligned to 5B boundaries	0
6	Baseline Wander Correction Disable	R/W	1 = Baseline wander correction disabled 0 = Baseline wander correction enabled	0
5	FEF Enable	R/W	1 = Far end fault enabled 0 = Far end fault disabled	0
4:3	Reserved ^a	R/W	Write as 0, Ignore when read	0
2	Extended FIFO Enable	R/W	1 = Extended FIFO mode, 0 = Normal FIFO mode	0
1	Reserved ^a	R/W	Write as 0, ignore when read	0
0	Reserved ^a	R/W	Write as 0, Ignore when read	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Transmit Disable

The transmitter can be disabled by writing a 1 to bit 13 of MII register 10h. The transmitter output (TD \pm) is forced into a high impedance state.

Bypass 4B5B Encoder/Decoder

The 4B5B encoder and decoder can be bypassed by writing a 1 to bit 10 of MII register 10h. The transmitter sends 5B codes from the TXER and TXD3, TXD2, TXD1, TXD0 pins directly to the scrambler. TXEN must be active and frame encapsulation (insertion of J/K and T/R codes) is not performed. The receiver places descrambled and aligned 5B codes onto the RXER, RXD3, RXD2, RXD1 and RXD0 pins. CRS can be asserted when a valid frame is received.

Bypass Scrambler/Descrambler

The stream cipher function can be disabled by writing a 1 to bit 9 of MII register 10h. The stream cipher function is re-enabled by writing a 0 to this bit.



Bypass NRZI Encoder/Decoder

The NRZI encoder and decoder can be bypassed by writing a 1 to bit 8 of MII register 10h, causing 3-level NRZ data to be transmitted and received on the cable. Normal operation (3-level NRZI encoding and decoding) can be re-enabled by writing a 0 to this bit.

Bypass Receive Symbol Alignment

Receive symbol alignment can be bypassed by writing a 1 to bit 7 of MII register 10h. When used in conjunction with the bypass 4B5B encoder/decoder bit, unaligned 5B codes are placed directly on the RXER and RXD1, RXD0 pins.

Baseline Wander Correction Disable

The baseline wander correction circuit can be disabled by writing a 1 to bit 6 of MII register 10h. The BCM5220 corrects for baseline wander on the receive data signal when this bit is cleared.

FEF Enable

Controls the far end fault mechanism associated with 100BASE-FX operation. A 1 enables the FEF function and a 0 disables it.

Reserved Bits

The reserved bits of the 100BASE-X Auxiliary Control register must be written as 0 at all times. Ignore the BCM5220 outputs when these bits are read.

100BASE-X AUXILIARY STATUS REGISTER

Table 18: 100BASE-X Auxiliary Status Register (Address 17d, 11h)

Bit	Name	R/W	Description	Default
15:12	Reserved ^a	RO	Ignore when read	0
11	Reserved ^a	RO	Ignore when read	0
10	FX Mode	RO	1 = 100BASE-FX mode 0 = 100BASE-TX or 10BASE-T mode	PIN
9	Locked	RO	1 = Descrambler locked 0 = Descrambler unlocked	0
8	Current 100BASE-X Link Status	RO	1 = Link pass 0 = Link fail	0
7	Remote Fault	RO	1 = Remote fault detected 0 = No remote fault detected	0
6	Reserved ^a	RO	Ignore when read	0
5	False Carrier Detected	RO LH	1 = False carrier detected since last read 0 = No false carrier since last read	0
4	Bad ESD Detected	RO LH	1 = ESD error detected since last read 0 = No ESD error since last read	0
3	Receive Error Detected	RO LH	1 = Receive error detected since last read 0 = No receive error since last read	0
2	Transmit Error Detected	RO LH	1 = Transmit error code received since last read 0 = No transmit error code received since last read	0
1	Lock Error Detected	RO LH	1 = Lock error detected since last read 0 = No lock error since last read	0
0	MLT3 Code Error Detected	RO LH	1 = MLT3 code error detected since last read 0 = No MLT3 code error since last read	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

FX Mode

Returns a value derived from the SD \pm input pins. Returns 1 when SD+ are driven with a valid differential signal level. Returns 0 when both SD+ and SD- are simultaneously driven low.

Locked

The PHY returns a 1 in bit 9 when the descrambler is locked to the incoming data stream. Otherwise it returns a 0.

Current 100BASE-X Link Status

The PHY returns a 1 in bit 8 when the 100BASE-X link status is good. Otherwise it returns a 0.

Remote Fault

The PHY returns a 1 while its link partner is signalling a far-end fault condition. Otherwise it returns a 0.



False Carrier Detected

The PHY returns a 1 in bit 5 of the Extended Status register if a false carrier has been detected since the last time this register was read. Otherwise it returns a 0.

Bad ESD Detected

The PHY returns a 1 in bit 4 if an end of stream delimiter error has been detected since the last time this register was read. Otherwise it returns a 0.

Receive Error Detected

The PHY returns a 1 in bit 3 if a packet was received with an invalid code since the last time this register was read. Otherwise it returns a 0.

Transmit Error Detected

The PHY returns a 1 in bit 2 if a packet was received with a transmit error code since the last time this register was read. Otherwise it returns a 0.

Lock Error Detected

The PHY returns a 1 in bit 1 if the descrambler has lost lock since the last time this register was read. Otherwise it returns a 0.

MLT3 Code Error Detected

The PHY returns a 1 in bit 0 if an MLT3 coding error has been detected in the receive data stream since the last time this register was read. Otherwise it returns a 0.

100BASE-X RECEIVE ERROR COUNTER

Table 19: 100BASE-X Receive Error Counter (Address 18d, 12h)

<i>Bit</i>	<i>Name</i>	<i>R/W</i>	<i>Description</i>	<i>DEFAULT</i>
15:8	Receive Error Counter	R/W	Write as 0, Ignore when read	0000h
7:0	Receive Error Counter	R/W	Number of non-collision packets with receive errors since last read	0000h

Receive Error Counter [15:0]

This counter increments each time the BCM5220 receives a non-collision packet containing at least one receive error. The counter automatically clears itself when read. When the counter reaches its maximum value, FFh, it stops counting receive errors until cleared.

100BASE-X FALSE CARRIER SENSE COUNTER

Table 20: 100BASE-X False Carrier Sense Counter (Address 19d, 13h)

Bit	Name	R/W	Description	DEFAULT
15:8	Reserved ^a	R/W	Write as 0, ignore when read	00h
7:0	False Carrier Sense Counter	R/W	Number of false carrier sense events since last read	00h

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

False Carrier Sense Counter [7:0]

This counter increments each time the BCM5220 detects a false carrier on the receive input. This counter automatically clears itself when read. When the counter reaches its maximum value, FFh, it stops counting False Carrier Sense Errors until cleared.

100BASE-X DISCONNECT COUNTER

Table 21: 100BASE-X Disconnect Counter (Address 20d, 14h)

Bit	Name	R/W	Description	DEFAULT
15	Reserved ^a	R/O	0 = Normal	0
14	Reserved ^a	R/O	0 = Normal	0
13:8	Reserved ^a	R/W	Write as 000010, ignore when read	000010
7:0	Reserved ^a	R/W	Write as 00h, ignore when read	00h

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

PTEST REGISTER

The bit description for the PTEST register is shown in Table 22.

Table 22: PTEST Register (Address 10111b, 23d, 17h)

Bit	Name	R/W	Description	DEFAULT
15:0	Reserved ^a	RO	Ignore when read	0000h

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."



AUXILIARY CONTROL/STATUS REGISTER

The Auxiliary Control/Status register bit descriptions are shown in Table 23.

Table 23: Auxiliary Control/Status Register (Address 24d, 18h)

Bit	Name	R/W	Description	Default
15	Jabber Disable	R/W	1 = Jabber function disabled 0 = Jabber function enabled	0
14	Force Link	R/W	1 = Force 10BASE-T link pass 0 = Normal 10BASE-T link operation	0
13:8	Reserved ^a	RO	Ignore when read	000000
7:6	HSQ : LSQ	R/W	These two bits define the squelch mode of the 10BASE-T Carrier Sense mechanism 00 = Normal Squelch 01 = Low Squelch 10 = High Squelch 11 = Not Allowed	00
5:4	Edge Rate [1:0]	R/W	00 = 1 ns 01 = 2 ns 10 = 3 ns 11 = 4 ns	11
3	Auto-Negotiation Indication	RO	1 = Auto-negotiation activated 0 = Speed forced manually	ANEN Pin
2	Force 100/10 Indication	RO	1 = Speed forced to 100BASE-X 0 = Speed forced to 10BASE-T	F100 Pin
1	Speed Indication	RO	1 = 100BASE-X 0 = 10BASE-T	
0	Full-Duplex Indication	RO	1 = Full-duplex active 0 = Full-duplex not active	FDX Pin

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Jabber Disable

10BASE-T operation only. Bit 15 of the Auxiliary Control register allows the user to disable the jabber detect function, defined in the IEEE standard. This function shuts off the transmitter when a transmission request has exceeded a maximum time limit. By writing a 1 to bit 15 of the Auxiliary Control register, the jabber detect function is disabled. Writing a 0 to this bit or resetting the chip restores normal operation. Reading this bit returns the value of jabber detect disable.

Link Force

Writing a 1 to bit 14 of the Auxiliary Control register allows the user to disable the Link Integrity state machines, and place the BCM5220 into forced link pass status. Writing a 0 to this bit or resetting the chip restores the Link Integrity functions. Reading this bit returns the value of the force link bit.

HSQ and LSQ

Extend or decrease the squelch levels for detection of incoming 10BASE-T data packets. The default squelch levels implemented are those defined in the IEEE standard. The high-and low-squelch levels are useful for situations where the IEEE-prescribed levels are inadequate. The squelch levels are used by the CRS/LINK block to filter out noise and recognize only valid packet preambles and link integrity pulses. Extending the squelch levels allows the BCM5220 to operate properly



over longer cable lengths. Decreasing the squelch levels can be useful in situations where there is a high level of noise present on the cables. Reading these 2 bits returns the value of the squelch levels.

Edge Rate

Control bits used to program the transmit DAC output edge rate in 100BASE-TX mode. A larger value on these bits produces slower transitions on the transmit waveform.

Auto-Negotiation Indication

This read-only bit indicates whether auto-negotiation has been enabled or disabled on the BCM5220. A combination of a 1 in bit 12 of the Control register and a logic 1 on the ANEN input pin is required to enable auto-negotiation. When auto-negotiation is disabled, bit 3 of the Auxiliary Control register (18h) returns a 0. At all other times, it returns a 1.

Force100/10 Indication

This read-only bit returns a value of 0 when one of following cases is true:

- The ANEN pin is low AND the F100 pin is low.
- The ANEN pin is high AND bit 12 of the Control register has been written 0 and bit 13 of the Control register has been written 0.

When bit 2 of the Auxiliary Control register (18h) is 0, the speed of the chip is 10BASE-T. In all other cases, either the speed is not forced (auto-negotiation is enabled), or the speed is forced to 100BASE-X.

Speed Indication

This read-only bit shows the true current operation speed of the BCM5220. A 1 indicates 100BASE-X operation, and a 0 indicates 10BASE-T. While the auto-negotiation exchange is performed, the BCM5201 is always operating at 10BASE-T speed.

Full-Duplex Indication

This read-only bit returns a 1 when the BCM5220 is in full-duplex mode. In all other modes, it returns a 0.

AUXILIARY STATUS SUMMARY REGISTER

The Auxiliary Status Summary register contains copies of redundant status bits found elsewhere within the MII register space. Descriptions for each of these individual bits can be found associated with their primary register descriptions. Table 24 indicates the bits found in this register.

Table 24: Auxiliary Status Summary Register (Address 25d, 19h)

Bit	Name	R/W	Description	Default
15	Auto-Negotiation Complete	RO	1 = Auto-negotiation process completed	0
14	Auto-Negotiation Complete Acknowledge	RO LH	1 = Auto-negotiation completed acknowledge state	0
13	Auto-Negotiation Acknowledge Detected	RO LH	1 = Auto-negotiation acknowledge detected	0
12	Auto-Negotiation Ability Detect	RO LH	1 = Auto-negotiation for link partner ability	0
11	Auto-Negotiation Pause	RO	BCM5220 and link partner pause operation bit	0
10:8	Auto-Negotiation HCD	RO	000 = No highest common denominator 001 = 10BASE-T 010 = 10BASE-T Full-Duplex 011 = 100BASE-TX 100 = 100BASE-T4 101 = 100BASE-TX Full-Duplex 11x = Undefined	000
7	Auto-Negotiation Parallel Detection Fault	RO LH	1 = Parallel detection fault	0
6	Link Partner Remote Fault	RO	1 = Link partner remote fault	0
5	Link Partner Page Received	RO LH	1 = New page has been received	0
4	Link Partner Auto-Negotiation Able	RO	1 = Link partner is auto-negotiation capable	0
3	Speed Indicator	RO	1 = 100 Mbps 0 = 10 Mbps	
2	Link Status	RO LL	1 = Link is up (link pass state)	0
1	Auto-Negotiation Enabled	RO	1 = Auto-negotiation enabled	ANEN pin
0	Jabber Detect	RO LH	1 = Jabber condition detected	0

Note: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = latched low, LH = latched high (LL and LH are cleared after read operation)

INTERRUPT REGISTER

Table 25: Interrupt Register (Address 26d, 1Ah)

Bit	Name	R/W	Description	Default
15	FDX LED Enable	R/W	1 = Enable full-duplex LED output on G7/34 0 = Enable XMTLED or Interrupt LED if Interrupt is enabled.	0
14	INTR Enable	R/W	Interrupt enable	0
13:12	Reserved ^a	RO	Ignore when read	00
11	FDX Mask	R/W	Full-duplex interrupt mask	1
10	SPD Mask	R/W	SPEED interrupt mask	1
9	LINK Mask	R/W	LINK interrupt mask	1
8	INTR Mask	R/W	Master interrupt mask	1
7:4	Reserved	RO	Ignore when read	000
3	FDX Change	RO LH	Duplex change interrupt	0
2	SPD Change	RO LH	Speed change interrupt	0
1	LINK Change	RO LH	Link change interrupt	0
0	INTR Status	RO LH	Interrupt status	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

FDX LED Enable

When this bit is set to a 1, FDX LED pin G7(BGA)/34(PQFP) will output FDX status. Otherwise, when INTR Enable is set to a 1 it will output Interrupt state. When both bits are 0, it will output XMT state.

Interrupt Enable

Setting this bit enables Interrupt Mode.

FDX Mask

When this bit is set, changes in Duplex mode will not generate an interrupt.

SPD Mask

When this bit is set, changes in operating speed will not generate an interrupt.

Link Mask

When this bit is set, changes in Link status will not generate an interrupt.



Interrupt Mask

Master Interrupt Mask. When this bit is set, no interrupts will be generated, regardless of the state of the other MASK bits.

FDX Change

A 1 indicates a change of Duplex status since last register read. Register read clears the bit.

SPD Change

A 1 indicates a change of Speed status since last register read. Register read clears the bit.

Link Change

A 1 indicates a change of Link status since last register read. Register read clears the bit.

Interrupt Status

Represents status of the INTR# pin. A 1 indicates that the interrupt mask is off and that one or more of the change bits are set. Register read clears the bit.

AUXILIARY MODE 2 REGISTER

Table 26: Auxiliary Mode 2 Register (Address 27d, 1Bh)

<i>Bit</i>	<i>Name</i>	<i>R/W</i>	<i>Description</i>	<i>Default</i>
15:12	Reserved ^a	RO	Ignore when read	0
11	10BASE-T Dribble Bit Correct	R/W	1 = Enable, 0 = Disable	0
10	Token Ring Mode	R/W	1 = Enable, 0 = Disable	0
9	HSTR FIFO Enable	R/W	1 = Enable, 0 = Disable	0
8	Reserved ^a	RO	Ignore when read	0
7	Block 10BT Echo Mode	R/W	1 = Enable, 0 = Disable	1
6	Traffic Meter LED Mode	R/W	1 = Enable, 0 = Disable	0
5	Activity LED Force On	R/W	1 = ON, 0 = Normal operation	0
4	Reserved ^a	R/W	Ignore when read	1
3	Reserved ^a	R/W	Write as 1, Ignore when read	1
2	Activity/Link LED Mode	R/W	1 = Enable, 0 = Disable	0
1	Qual Parallel Detect Mode	R/W	1 = Enable, 0 = Disable	1
0	Reserved ^a	RO	Ignore when read	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

10BASE-T Dribble Bit Correct

When enabled, the PHY rounds down to the nearest nibble when dribble bits are present on the 10BASE-T input stream.



Token Ring Mode

When enabled, the 100BASE-X unlock timer changes to allow long packets.

Block 10BASE-T Echo Mode

When enabled, during 10BASE-T half-duplex transmit operation, the TXEN signal does not echo onto the RXDV pin. The TXEN echoes onto the CRS pin and the CRS deassertion directly follows the TXEN deassertion.

Traffic Meter LED Mode

When enabled, the Activity LEDs (ACTLED# and FDXLED# if full-duplex LED and interrupt LED modes are not enabled) does not blink based on the internal LED clock (approximately 80 ms on time). Instead, they blink based on the rate of Receive and Transmit activity. Each time a Receive or Transmit operation occurs, the LED turns on for a minimum of 5 ms. During light traffic, the LED blinks at a low rate, while during heavier traffic the LEDs remains on.

Activity LED Force On

When asserted, the Activity LEDs (ACTLED# and FDXLED# if full-duplex LED and interrupt LED modes are not enabled) is turned on. This bit has a higher priority than the Activity LED force Inactive, bit 4, register 1Dh.

Activity/Link LED Mode

When enabled, the RCVLED# output goes active upon acquiring link and pulses during Receive or Transmit activity.

Qualified Parallel Detect Mode

This bit allows the auto-negotiation/parallel detection process to be qualified with information in the Advertisement register. If this bit is not set, the local BCM5220 device is enabled to auto-negotiate, and the far-end device is a 10BASE-T or 100BASE-X non-auto-negotiating legacy type, the local device auto-negotiate/parallel detects the far-end device, regardless of the contents of its Advertisement register (04h).

If this bit is set, the local device compares the link speed detected to the contents of its Advertisement register. If the particular link speed is enabled in the Advertisement register, the local device asserts link. If the link speed is disabled in this register, then the local device does not assert link and continues monitoring for a matching capability link speed.

10BASE-T AUXILIARY ERROR & GENERAL STATUS REGISTER

Table 27: 10BASE-T Auxiliary Error & General Status Register (Address 28d, 1Ch)

Bit	Name	R/W	Description	Default
15:11	Reserved ^a	RO	Ignore when read	00001
10	Manchester Code Error	RO	1 = Manchester code error (10BASE-T)	0
9	End Of Frame Error	RO	1 = EOF detection error (10BASE-T)	0
8	Reserved ^a	RO	Ignore when read	0
7:5	Reserved ^a	RO	Ignore when read	001
4	Reserved ^a	RO	Ignore when read	0
3	Auto-Negotiation Indication	RO	1 = Auto-negotiation activated 0 = Speed forced manually	1
2	Force 100/10 Indication	RO	1 = Speed forced to 100BASE-X 0 = Speed forced to 10BASE-T	1
1	Speed Indication	RO	1 = 100BASE-X 0 = 10BASE-T	0
0	Full-duplex Indication	RO	1 = Full-duplex active 0 = Full-duplex not active	0

Note: All Error bits in the Auxiliary Error and General Status register are read-only and are latched high. When certain types of errors occur in the BCM5201, one or more corresponding error bits become "1". They remain so until the register is read, or until a chip reset occurs. All such errors necessarily result in data errors, and are indicated by a high value on the RXER output pin at the time the error occurs.

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Manchester Code Error

Indicates that a Manchester code violation was received. This bit is only valid during 10BASE-T operation.

End of Frame Error

Indicates that the End Of Frame (EOF) sequence was improperly received, or not received at all. This error bit is only valid during 10BASE-T operation.

Auto-Negotiation Indication

This read-only bit indicates whether auto-negotiation has been enabled or disabled on the BCM5220. A combination of a 1 in bit 12 of the Control register and a logic 1 on the ANEN input pin is required to enable auto-negotiation. When auto-negotiation is disabled, bit 15 of the Auxiliary Mode register returns a 0. At all other times, it returns a 1.

Force 100/10 Indication

This read-only bit returns a value of 0 when one of following two cases is true:

- The ANEN pin is low AND the F100 pin is low. (or)
- Bit 12 of the Control register has been written 0 AND bit 13 of the Control register has been written 0.



When bit 2 of the Auxiliary Control register is 0, the speed of the chip is 10BASE-T. In all other cases, either the speed is not forced (auto-negotiation is enabled), or the speed is forced to 100BASE-X.

Speed Indication

This read-only bit shows the true current operation speed of the BCM5220. A 1 bit indicates 100BASE-X operation, while a 0 indicates 10BASE-T. While the auto-negotiation exchange is performed, the BCM5220 is always operating at 10BASE-T speed.

Full-Duplex Indication

This read-only bit returns a 1 when the BCM5220 is in full-duplex mode. In all other modes, it returns a 0.

AUXILIARY MODE REGISTER

Table 28 shows the bit descriptions for the Auxiliary Mode register.

Table 28: Auxiliary Mode Register (Address 29d, 1Dh)

Bit	Name	R/W	Description	Default
15:13	Reserved ^a	RO	Ignore when read	
12	Alternative Link LED Mode	R/W	1 = LNKLED# indicates link at 100Base-TX, SPDLED# indicates link at 10BASE-T. 0 = Normal operation for LNKLED# and SPDLED#.	0
11:5	Reserved ^a	RO	Ignore when read	0
4	Activity LED Disable	R/W	1 = Disable XMT/RCV activity LED outputs 0 = Enable XMT/RCV activity LED outputs	0
3	Link LED Disable	R/W	1 = Disable link LED output 0 = Enable link LED output	0
2	Reserved ^a	RO	Ignore when read	
1	Block TXEN Mode	R/W	1 = Enable block TXEN mode 0 = Disable block TXEN mode	0
0	Reserved ^a	RO	Ignore when read	0

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Activity LED Disable

When set to 1, disables the XMTLED# and RCVLED# output pins. When 0, XMTLED# and RCVLED# output pins are enabled.

Link LED Disable

When set to 1, disables the Link LED output pin. When 0, Link LED output is enabled.

Block TXEN Mode

When this mode is enabled, short IPGs of 1, 2, 3 or 4 TXC cycles results in the insertion of two IDLEs before the beginning of the next packet's JK symbols.

AUXILIARY MULTIPLE PHY REGISTER

Table 29: Auxiliary Multiple PHY Register (Address 30d, 1Eh)

Bit	Name	R/W	Description	Default
15	HCD_TX_FDX	RO	1 = Auto-negotiation result is 100BASE-TX full-duplex	0
14	HCD_T4	RO	1 = Auto-negotiation result is 100BASE-T4	0
13	HCD_TX	RO	1 = Auto-negotiation result is 100BASE-TX	0
12	HCD_10BASE-T_FDX	RO	1 = Auto-negotiation result is 10BASE-T full-duplex	0
11	HCD_10BASE-T	RO	1 = Auto-negotiation result is 10BASE-T	0
10:9	Reserved ^a	RO	Ignore when read	00
8	Restart Auto-Negotiation	R/W (SC)	1 = Restart auto-negotiation process 0 = (No effect)	0
7	Auto-Negotiation Complete	RO	1 = Auto-negotiation process completed 0 = Auto-negotiation process not completed	0
6	Acknowledge Complete	RO	1 = Auto-negotiation acknowledge completed	0
5	Acknowledge Detected	RO	1 = Auto-negotiation acknowledge detected	0
4	Ability Detect	RO	1 = Auto-negotiation waiting for LP ability	0
3	Super Isolate	R/W	1 = Super isolate mode 0 = Normal operation	0
2	Reserved ^a	RO	Ignore when read	0
1	10BASE-T Serial Mode	R/W	1 = Enable 10BASE-T serial mode 0 = Disable 10BASE-T serial mode	0
0	Reserved ^a	R/W	Write as 0, Ignore when read	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

- a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

HCD Bits

Bits 15:11 of the Auxiliary Multiple PHY register are 5 read-only bits that report the Highest Common Denominator (HCD) result of the auto-negotiation process. Immediately upon entering the link pass state after each reset or restart auto-negotiation, only 1 of these 5 bits is 1. The link pass state is identified by a 1 in bit 6 or 7 of this register. The HCD bits are reset to 0 every time auto-negotiation is restarted or the BCM5220 is reset. For their intended application, these bits uniquely identify the HCD only after the first link pass after reset or restart of auto-negotiation. On later Link Fault and subsequent re-negotiations, if the ability of the link partner is different, more than 1 of the above bits can be active.

Restart Auto-Negotiation

This self-clearing bit allows the auto-negotiation process to be restarted, regardless of the current status of the state machine. For this bit to work, auto-negotiation must be enabled. Writing a 1 to this bit restarts auto-negotiation. Since the bit is self-clearing, it always returns a 0 when read. The operation of this bit is identical to bit 9 of the Control register.

Auto-Negotiation Complete

This read-only bit returns a 1 after the auto-negotiation process has been completed. It remains 1 until the auto-negotiation process is restarted, a Link Fault occurs, or the chip is reset. If auto-negotiation is disabled or the process is still in progress, the bit returns a 0.

Acknowledge Complete

This read-only bit returns a 1 after the acknowledgment exchange portion of the auto-negotiation process has been completed and the Arbitrator state machine has exited the Complete Acknowledge state. It remains this value until the auto-negotiation process is restarted, a Link Fault occurs, auto-negotiation is disabled, or the BCM5220 is reset.

Acknowledge Detected

This read-only bit is set to 1 when the arbitrator state machine exits the acknowledged detect state. It remains high until the auto-negotiation process is restarted, or the BCM5220 is reset.

Ability Detect

This read-only bit returns a 1 when the auto-negotiation state machine is in the Ability Detect state. It enters this state a specified time period after the auto-negotiation process begins, and exits after the first FLP burst or link pulses are detected from the link partner. This bit returns a 0 any time the auto-negotiation state machine is not in the Ability Detect state.

Super Isolate

Writing a 1 to this bit places the BCM5201 into the Super Isolate mode. Additionally, all link pulses are suppressed. This allows the BCM5201 to coexist with another PHY on the same adapter card, with only one being activated at any time.

10BASE-T Serial Mode

Writing a 1 to bit 1 of the Auxiliary Mode register enables the 10BASE-T Serial mode. In the special 10BASE-T Serial mode, data packets traverse to the MAC layer across only TXD0 and RXD0 at a rate of 10 MHz. Serial operation is not available in 100BASE-X mode.

BROADCOM TEST REGISTER

Table 30: *Broadcom Test (Address 31d, 1Fh)*

Bit	Name	R/W	Description	Default
15:8	Reserved ^a	RO	Ignore when read	00h
7	Shadow register enable	R/W	1 = Enable shadow registers 0 = Disable shadow registers	0
6	Reserved ^a	RO	Ignore when read	0
5	Reserved ^a	R/W	Write as 0, Ignore when read	0
4:0	Reserved ^a	R/W	Write as 0Bh, Ignore when read	0Bh

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s).

- a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Shadow Register Enable

Writing a 1 to bit 7 of register 1Fh allows R/W access to the shadow registers.

AUXILIARY MODE 4 REGISTER (SHADOW REGISTER)

Table 31: Auxiliary Mode 4 Register (Shadow Register 26d, 1Ah)

Bit	Name	R/W	Description	Default
15:6	Reserved ^a	R/W	Write as 30h, Ignore when read	30h
5:4	Force LED [1:0]	R/W	01 = Force all LED status to on 0 state 10 = Force all LED status to off 1 state	00
3	Reserved ^a	R/W	Write as 0, Ignore when read	0
2	Enable Clock During Low Power	R/W	0 = Disables clock during low power modes 1 = Enables clock during low power modes	0
1	Force Low Power Mode	R/W	0 = Normal operation 1 = Forces the 5220 to enter the low power mode	0
0	Force IDDQ Mode	R/W	0 = Normal operation 1 = Causes the BCM5220 to go to IDDQ mode	0

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s). MII Shadow register bank 1 is accessed by setting MII register 1Fh bit 7 to a 1.

- a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Force LED [1:0]

The SPDLED#, LNKLED#, XMTLED#, RCDLED#, COL_LED#, ACT_LED# and FDX_LED# outputs can be forced to on state (0) by writing a value of 01 to Force LED [1:0]. These LEDs can be forced to off state (1) by writing a value of 10 to Force LED [1:0].

Enable Clock During Low Power

If this bit is set to a 1 then the clocks are running in low mode.

Force IDDQ Mode.

If this bit is set to a 1, then the BCM5220 enters IDDQ mode. When the device is in IDDQ mode, everything is disabled. The BCM5220 requires a hard reset to return to normal mode.

AUXILIARY STATUS 2 REGISTER (SHADOW REGISTER)

Table 32: Auxiliary Status 2 Register (Shadow Register 27d, 1Bh)

Bit	Name	R/W	Description	Default
15	MLT3 Detected	R/O	1 = MLT3 Detected	0h
14:6	Reserved ^a	R/O		000h
5	APD Enable	R/W	0 = Normal mode 1 = Enable auto power down mode	0
4	APD Sleep Timer	R/W	0 = 2.5 sec sleep before wake-up 1 = 5.0 sec sleep before wake-up	0
3:0	APD Wake-up Timer [3:0]	R/W	Duration of wake-up	0001

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s). MII Shadow register bank 1 is accessed by setting MII register 1Fh bit 7 to a 1.

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

MLT3 Detected

The BCM5220 returns a 1 in this bit whenever MLT3 signaling is detected.

APD Enable

When in normal mode, if this bit set to a 1, the BCM5220 enters auto power down mode. If this bit is set, the BCM5220 enters low power mode whenever the link is lost. When energy is detected the device enters full power mode. Otherwise, it wakes-up after 2.5s or 5.0s, as determined by the APD Sleep Timer bit. When the BCM5220 wakes up, it sends link pulses and monitors energy. If the link partner's energy is detected then the BCM5220 enters full power mode and establishes a link with the Link partner. If no energy is detected from the link partner, it continues to stay in wake-up mode for a duration determined by the APD Wake-up Timer before going to low power mode.

APD Sleep Timer

This bit determines how long the BCM5220 stays in low power mode before wake-up. If this bit is a 0, then it waits approximately 2.5s before wake-up, else 5s.

APD Wake-up Timer [3:0]

This counter determines how long the BCM5220 stays up in wake-up mode before going to low-power mode. This value is specified in 40-ms increments from 0 to 600 ms. A value of 0 forces the BCM5220 to stay in low-power mode indefinitely. In this case the BCM5220 requires a hard reset to return to normal mode.



AUXILIARY STATUS 3 REGISTER (SHADOW REGISTER)

Table 33: Auxiliary Status 3 Register (Shadow Register 28d, 1Ch)

Bit	Name	R/W	DESCRIPTION	Default
15:4	Reserved ^a	R/W	Write as 000h, ignore when read	000h
3:0	FIFO Consumption [3:0]	R/O	Currently utilized number of nibbles in the receive FIFO	0000

MII Shadow register bank 1 is accessed by setting MII register 1Fh bit 7 to a 1

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

Noise [7:0]

The BCM5220 provides the current mean squared error value for noise when a valid link is established.

FIFO Consumption [3:0]

The BCM5220 indicates the number of nibbles of FIFO currently used.

AUXILIARY MODE 3 REGISTER (SHADOW REGISTER)

Table 34: Auxiliary Mode 3 Register (Shadow Register 29d, 1Dh)

Bit	Name	R/W	Description	Default
15:9	Reserved ^a	R/W	Write as 00h, ignore when read	0
8	Reserved ^a	R/W	Write as 0, ignore when read	0
7	Reserved ^a	R/W	Write as 0, ignore when read	0
6	Reserved ^a	R/W	Write as 0, ignore when read	0
5:4	Reserved ^a	R/W	Write as 00, ignore when read	0h
3:0	FIFO Size Select [3:0]	R/W	Currently selected receive FIFO Size	4h

Notes: R/W = Read/Write, RO = Read only, SC = Self Clear, LL = Latched Low, LH = Latched High, LL & LH Clear after read operation. Use default values of reserved bit(s) when writing to reserved bit(s). MII Shadow register bank 1 is accessed by setting MII register 1Fh bit 7 to a 1.

a. Preserve existing values of reserved bits by completing a "Read/Modify Write."

FIFO Size Select [3:0]

The BCM5220 indicates the current selection of receive FIFO size using bit 3 through 0 as shown in Table 35.

Table 35: Current Receive FIFO Size

<i>FIFO Size Select [3:0]</i>	<i>Receive FIFO Size in Use (# of bits)</i>
0001	16
0010	20
0011	24
0100	28
0101	32
0110	36
0111	40
1000	44
1001	48
1010	52
1011	56
1100	60
1101	64

AUXILIARY STATUS 4 REGISTER (SHADOW REGISTER)

Table 36: Auxiliary Status 4 Register (Shadow Register 30d, 1Eh)

<i>Bit</i>	<i>Name</i>	<i>R/W</i>	<i>Description</i>	<i>Default</i>
15:0	Packet Length Counter[15:0]	R/O	Number of bytes in the last received packet	0000h

Packet Length Counter [15:0]

The BCM5220 shows the number bytes in the last packet received. This is valid only when a valid link is established.

Section 6: Timing and AC Characteristics

The timing information contained in this section applies to the BCM5220.

All MII Interface pins comply with IEEE 802.3u timing specifications (see Reconciliation Sublayer and Media Independent Interface in IEEE 802.3u timing specifications). All digital output timing specified at $C_L = 30$ pF.

Output rise/fall times measured between 10% and 90% of the output signal swing. Input rise/fall times measured between V_{IL} max. and V_{IH} min. Output signal transitions referenced to the midpoint of the output signal swing. Input signal transitions referenced to the midpoint between V_{IL} max. and V_{IH} min. See Table 37 and Table 38 for the timing parameters. See Figure 3 for an illustration of clock and reset timing.

Table 37: Clock Timing

<i>Parameter</i>	<i>Symbol</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>
XTALI Cycle Time	CK_CYCLE	39.998	40	40.002	ns
XTALI High/Low Time	CK_HI CK_LO	14	20	26	ns
REF_CLK Cycle Time (MII - 25 MHz)			40		ns
REF_CLK High/Low Time (MII - 25 MHz)		13	20	27	ns
REF_CLK Rise/Fall Time (MII - 25 MHz)				4	ns
REF_CLK Cycle Time (RMII - 50 MHz)			20	2	ns
REF_CLK High/Low Time (RMII - 50 MHz)		7	10	13	ns
REF_CLK Rise/Fall Time (RMII - 50 MHz)				2	ns

Table 38: Reset Timing

<i>Parameter</i>	<i>Symbol</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>
Reset Pulse Length with stable XTALI Input (see note)	RESET_LEN	400			ns
Activity after end of Hardware Reset	RESET_WAIT	100			μs
RESET# Rise/Fall Time	RESET_EDGE			10	ns
Note: During power-on, RESET# pin must be held low to get the BCM5220 to power-up in normal mode.					



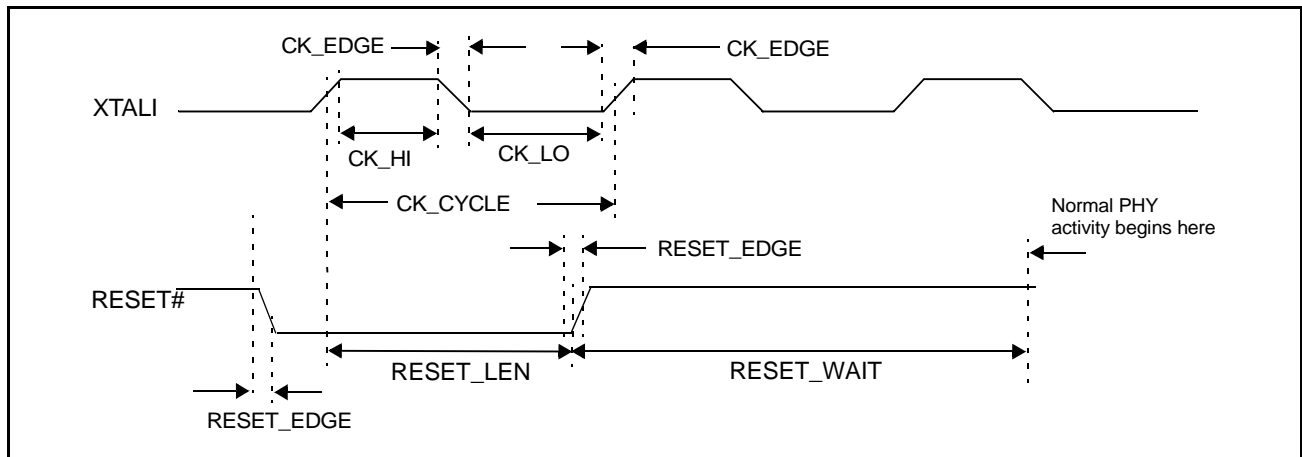


Figure 3: Clock and Reset Timing

Table 39 provides the parameters for 100BASE-X transmit timing. Figure 4 illustrates the 100BASE-TX transmit start of packet timing and Figure 5 on page 60 shows the 100BASE-TX transmit end of packet timing.

Table 39: MII 100BASE-X Transmit Timing

Parameter	Symbol	Min	Typ	Max	Unit
TXC Cycle Time			40		ns
TXC High/Low Time		16	20	24	ns
TXC Rise/Fall Time		2		5	ns
TXEN, TXD[3:0] Setup Time to TXC rising	TXEN_SETUP	10			ns
TXEN, TXD[3:0] Hold Time from TXC rising	TXEN_HOLD	0			ns
TD± after TXEN Assert (unsampled)	TXEN_TDATA		100		ns
TXD to TD± Steady State Delay	TXD_TDATA		100		ns
CRS Assert after TXEN Assert	TXEN_CRIS		11		ns
CRS Deassert after TXEN Deassert	TXEN_CRIS_EOP		11		ns
COL Assert after TXEN Assert (while RX)	TXEN_COL		17		ns
COL Deassert after TXEN Deassert (while RX)	TXEN_COL_EOP		17		ns

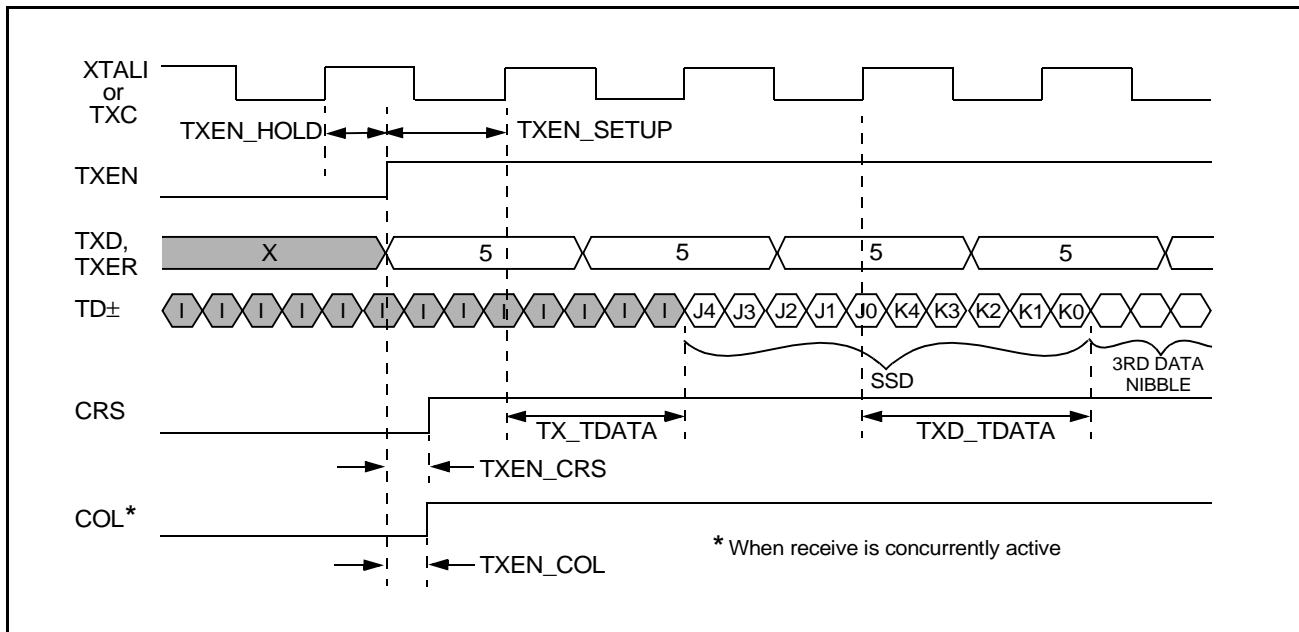


Figure 4: MII Transmit Start of Packet Timing (100BASE-TX)

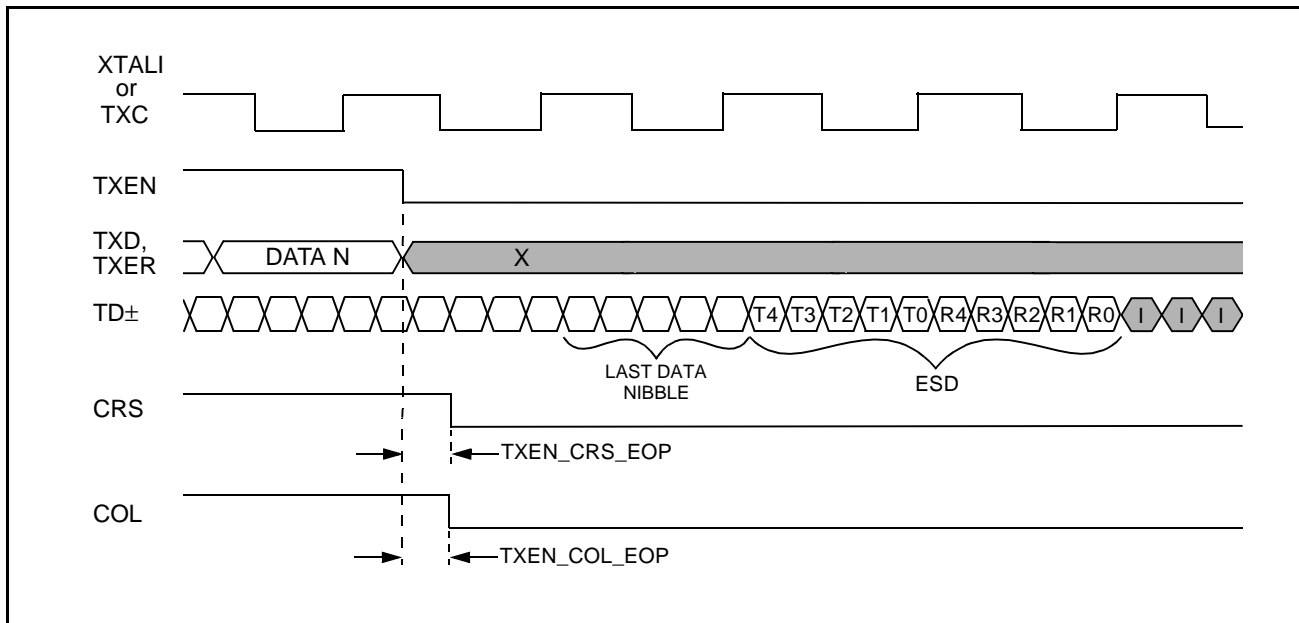


Figure 5: MII Transmit End of Packet Timing (100BASE-TX)

Table 40 below provides 10BASE-X receive timing parameters. See Figure 6 on page 61 and Figure 7 on page 62 for illustrations of 100BASE-TX receive start of packet timing parameters and 100BASE-TX receive end of packet timing. Figure 8 on page 62 shows 100BASE-TX receive packet premature end. See Figure 9 on page 63 for an illustration of link failure or stream cipher error during receive packet. 100BASE-TX False carrier sense timing is shown in Figure 10 on page 63.

Table 40: MII 100BASE-X Receive Timing

Parameter	Symbol	Min	Typ	Max	Unit
RXC Cycle Time			40		ns
RXC High/Low Time (RXDV asserted)			20		ns
RXC High Time (RXDV deasserted)			20		ns
RXC Low Time (RXDV deasserted)			20		ns
RXC Rise/Fall Time		2		5	ns
RXDV, RXER, RXD[3:0] Delay from RXC falling		-4		4	ns
CRS Deassert from RXC falling (valid EOP only)			1		ns
CRS Assert after RD±	RX_CRS		130		ns
CRS Deassert after RD± (valid EOP)	RX_CRS_EOP		170		ns
CRS Deassert after RD± (premature end)	RX_CRS_IDLE		165		ns
RXDV Assert after RD±	RX_RXDV		165		ns
RXDV Deassert after RD± (valid EOP)	RX_RXDV_EOP		170		ns
RXDV Assert after CRS			40		ns
RD± to RXD Steady State Delay	RX_RXD		170		ns
COL Assert after RD± (while TX)	RX_COL		125		ns
COL Deassert after RD± (valid EOP)	RX_COL_EOP		175		ns
COL Deassert after RD± (premature end)	RX_COL_IDLE		165		ns

Note: RXC minimum high and low times are guaranteed when RXEN is asserted or deasserted. The MII port will always tristate while RXEN is low.

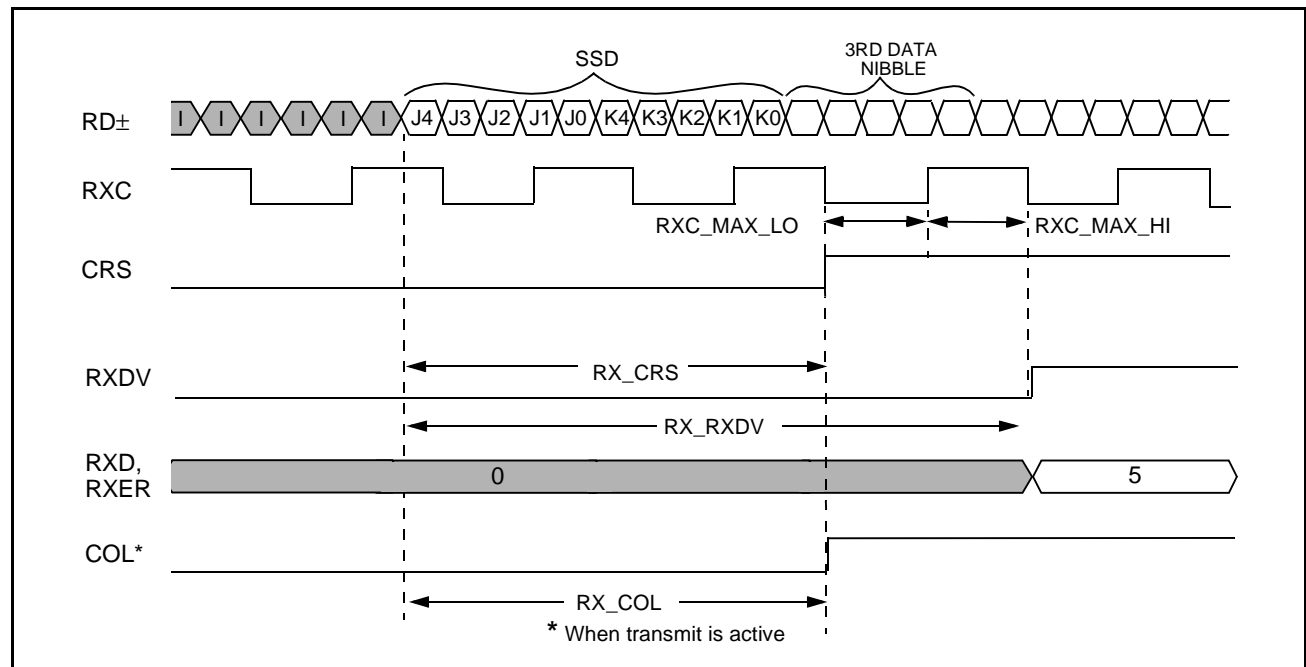


Figure 6: MII Receive Start of Packet Timing (100BASE-TX)

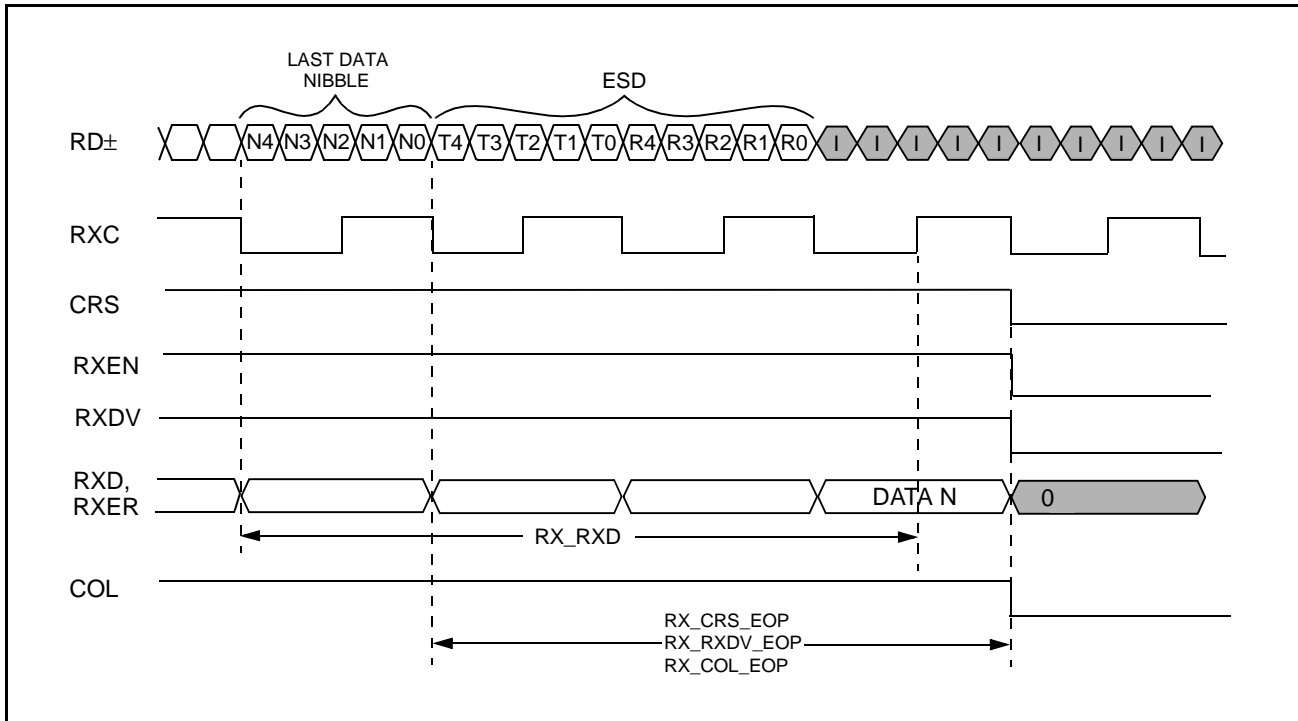


Figure 7: MII Receive End of Packet Timing (100BASE-TX)

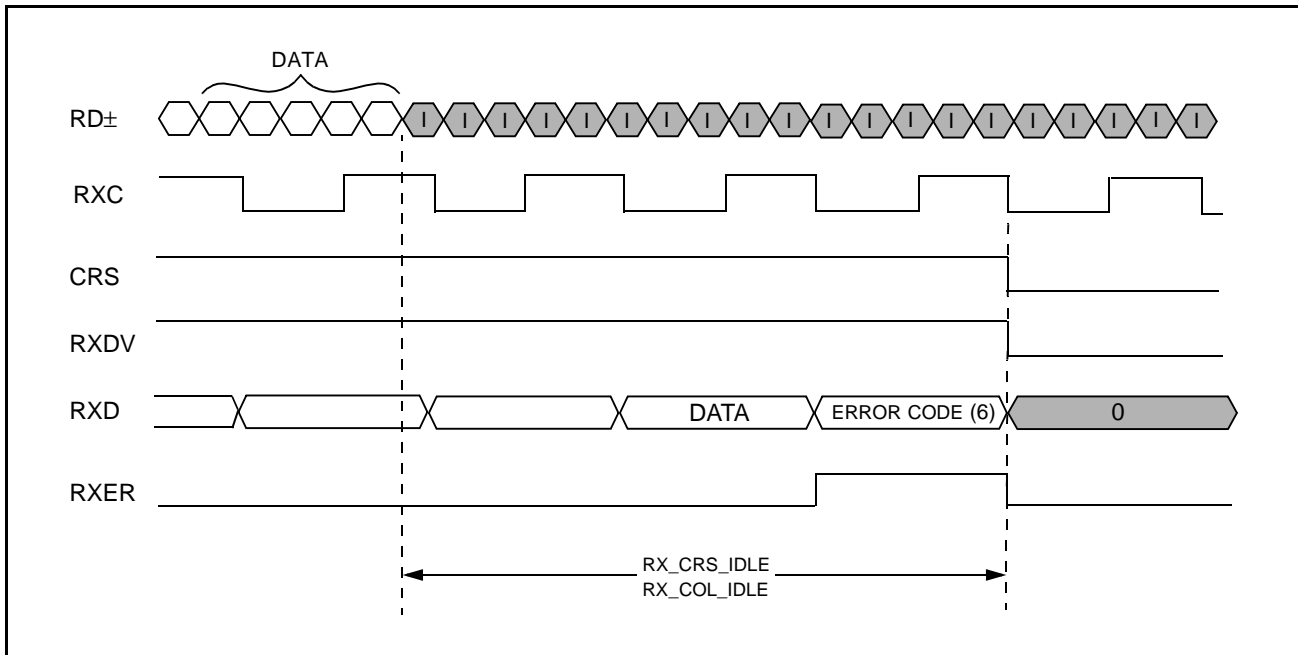


Figure 8: MII Receive Packet Premature End (100BASE-TX)



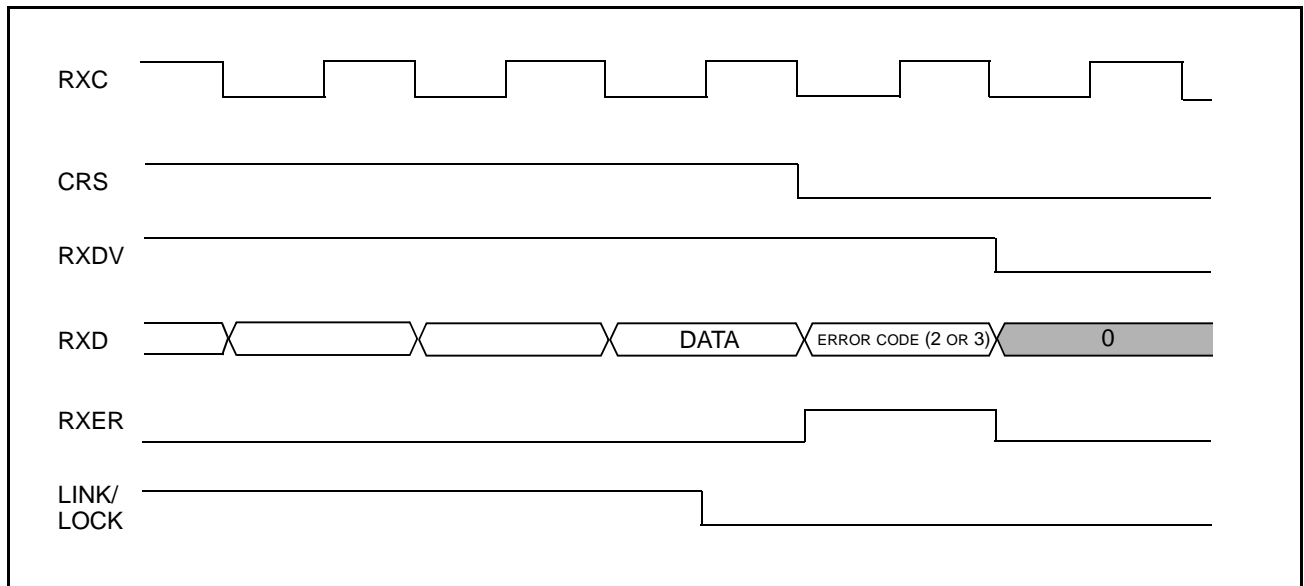


Figure 9: MII Link Failure or Stream Cipher Error During Receive Packet

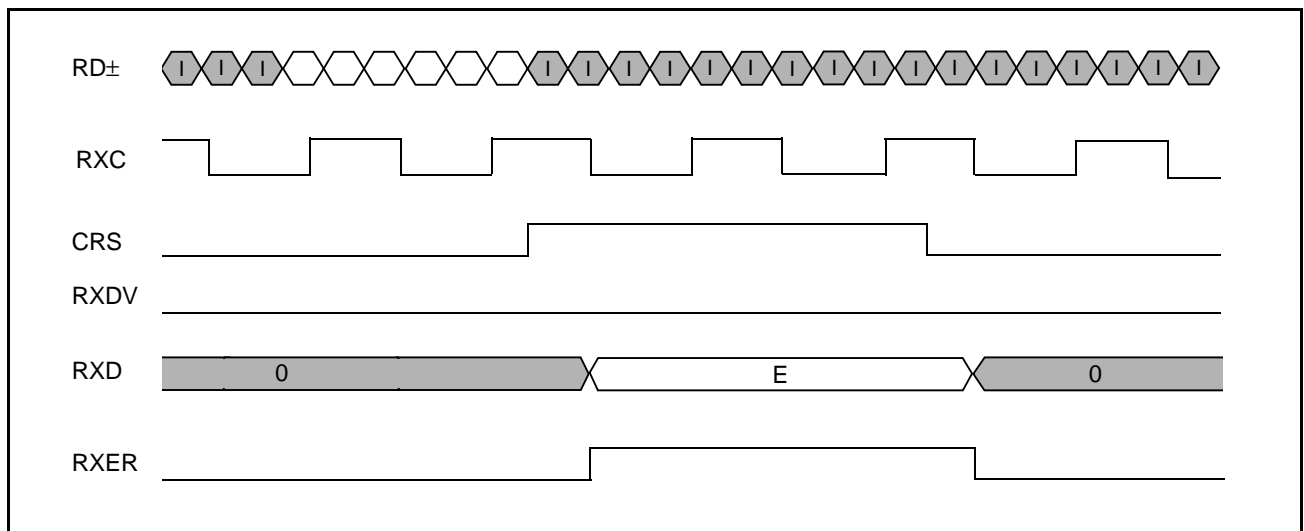


Figure 10: MII False Carrier Sense Timing (100BASE-TX)

Table 41 provides the parameters for 10BASE-T transmit timing. Figure 11 illustrates 10BASE-T transmit start of timing packet.

Table 41: MII 10BASE-T Transmit Timing

Parameter	Symbol	Min	Typ	Max	Unit
TXC Cycle Time (10BASE-T)	TXC_CYCLE	395	400	405	ns

Note: TXD, TXEN delivered to the BCM5220 should be generated of the rising edge of TXC.



Table 41: MII 10BASE-T Transmit Timing

Parameter	Symbol	Min	Typ	Max	Unit
TXC High/Low Time (10BASE-T)		197.5	200	202.5	ns
TXC Rise/Fall Time		2		5	ns
TXC Rising edge to TXEN valid	TXC_TXEN_VALID			25	ns
TXC Rising edge to TXEN hold	TXC_TXEN_HOLD	75			ns
TXC Rising edge to TXD valid	TXC_TXD_VALID			25	ns
TXC Rising edge to TXD hold	TXC_TXD_HOLD	75			ns
TD± after TXEN Assert	TXEN_TDATA		400		ns
CRS Assert after TXEN Assert	TXEN_CRIS		60		ns
CRS Deassert after TXEN Deassert	TXEN_CRIS_EOP		60		ns
Idle on Twisted Pair after TXEN De-Assert (sampled)	TX_QUIET		400		ns

Note: TXD, TXEN delivered to the BCM5220 should be generated of the rising edge of TXC.

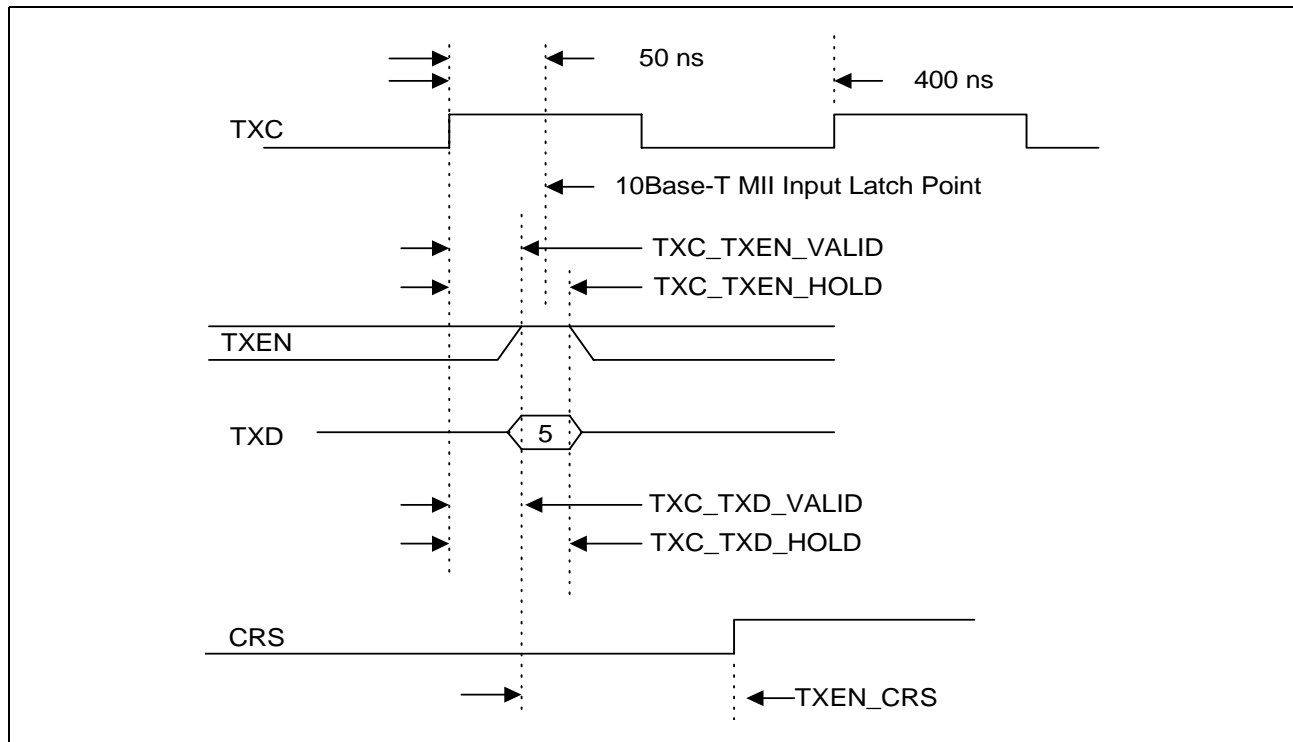


Figure 11: MII 10BASE-T Transmit Start of Packet Timing

Table 42 provides the parameters for MII 10BASE-T receive timing. MII 10BASE-T collision timing is shown in Table 43.

Table 42: MII 10BASE-T Receive Timing

Parameter	Symbol	Min	Typ	Max	Unit
RXC Cycle Time	RXC_CYCLE		400		ns



Table 42: MII 10BASE-T Receive Timing

Parameter	Symbol	Min	Typ	Max	Unit
RXC High/Low Time			200		ns
CRS Assert after Receive Analog Data	RX_CRD_BT		230		ns
RXC Valid after CRS Assert	RXC_VALID		1.7		μs
RXDV Assert after Receive Analog Data	RX_RXDV		1.2		μs
RXDV Deassert after Receive Analog EOP ends	RX_NOT_RXDV		400		ns
CRS Deassert after Receive Analog EOP ends	RX_NOT_CRD		400		ns

Table 43: MII 10BASE-T Collision Timing

Parameter	Symbol	Min	Typ	Max	Unit
COL Assert after Receive Analog (while transmitting)	RX_COL		220		ns
COL Deassert after TXEN Deassert (while receiving)	TXEN_NOT_COL		400		ns
COL Assert after TXEN Assert (while receiving)	TXEN_COL		50		ns
COL Deassert after Receive Analog ends (while transmitting)	RX_NOT_COL		200		ns

Table 44 provides the parameters for 10BASE-T serial transmit timing. Figure 12 illustrates 10BASE-T serial transmit start of timing packet.

Table 44: 10BASE-T Serial Transmit Timing

Parameter	Symbol	Min	Typ	Max	Unit
TXC Cycle Time	TXC	95	100	105	ns
TXC Low Time	TXC_LO	97.5		102.5	ns
TXC High Time	TXC_HIGH				
TXC Rise Time	TXC_RISE	2		5	ns
TXC Fall Time	TXC_FALL				
TXEN, TXD0 to TXC Rising	TXEN_SETUP	10			ns
TXEN, TXD0 Hold after TXC Rising	TXEN_HOLD	0			ns
TXEN to TD± Start	TXEN_TDATA		350		ns
TXEN to TD± End	TXEN_QUIET		400		ns

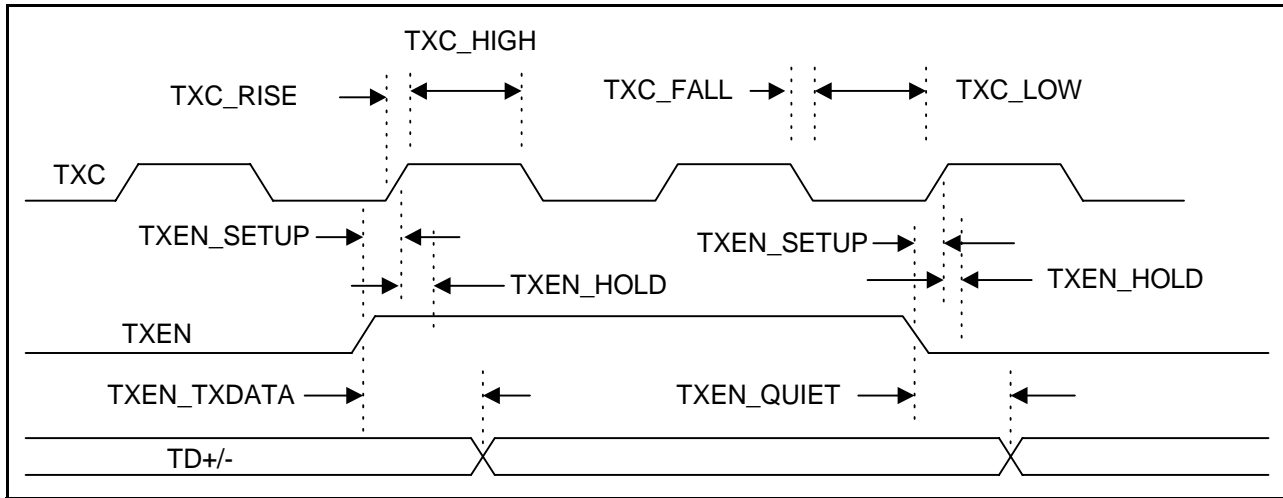


Figure 12: 10BASE-T Serial Transmit Timing

Table 45 provides the parameters for 10BASE-T serial receive timing. Figure 13 illustrates 10BASE-T serial receive start of timing packet.

Table 45: 10BASE-T Serial Receive Timing

Parameter	Symbol	Min	Typ	Max	Unit
RXC to RXD0 Output Delay	RXD_DELAY			5	ns
CRS Assert after RD±	RX_CRSDV		220		ns
CRS Deassert after RD±, valid EOP	RX_NOT_CRSDV		270		ns

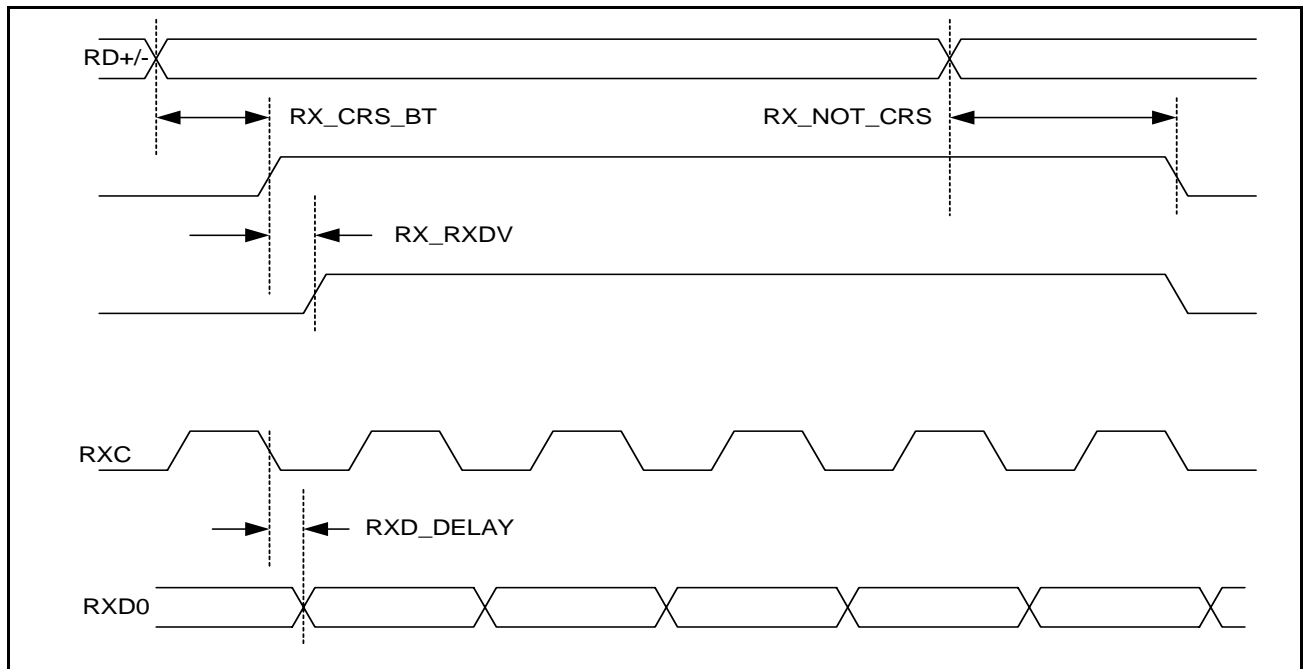


Figure 13: 10BASE-T Serial Receive Timing

Table 46, Table 47, and Table 48 provide the parameters for loopback timing, auto-negotiation timing, and LED timing.

Table 46: Loopback Timing (MII)

Parameter	Symbol	Min	Typ	Max	Unit
TXD to RXD Steady State Propagation Delay			184		ns

Table 47: Auto-Negotiation Timing

Parameter	Symbol	Min	Typ	Max	Unit
Link Test Pulse Width			100		ns
FLP Burst Interval			16		ms
Clock Pulse to Clock Pulse			123		µs
Clock Pulse to Data Pulse (Data = 1)			62.5		µs

Table 48: LED Timing

Parameter	Symbol	Min	Typ	Max	Unit
LED On Time (XMTLED#, RCVLED#, ACTLED#)			80		ms
LED Off Time (XMTLED#, RCVLED#, ACTLED#)			80		ms



Management data interface timing parameters are described in Table 49. Figure 14 and Figure 15 illustrate two types of management interface timing.

Table 49: Management Data Interface Timing

Parameter	Symbol	Min	Typ	Max	Unit
MDC Cycle Time		40			ns
MDC High/Low		20			ns
MDC Rise/Fall Time				10	ns
MDIO Input Setup Time to MDC rising		10			ns
MDIO Input Hold Time from MDC rising		10			ns
MDIO Output Delay from MDC rising		0		30	ns

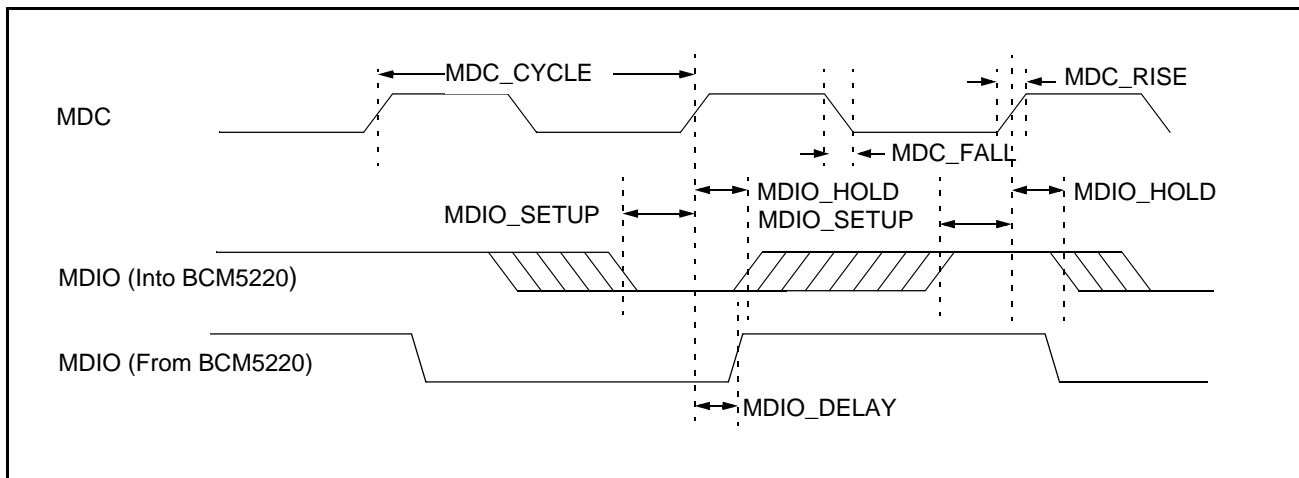


Figure 14: Management Interface Timing

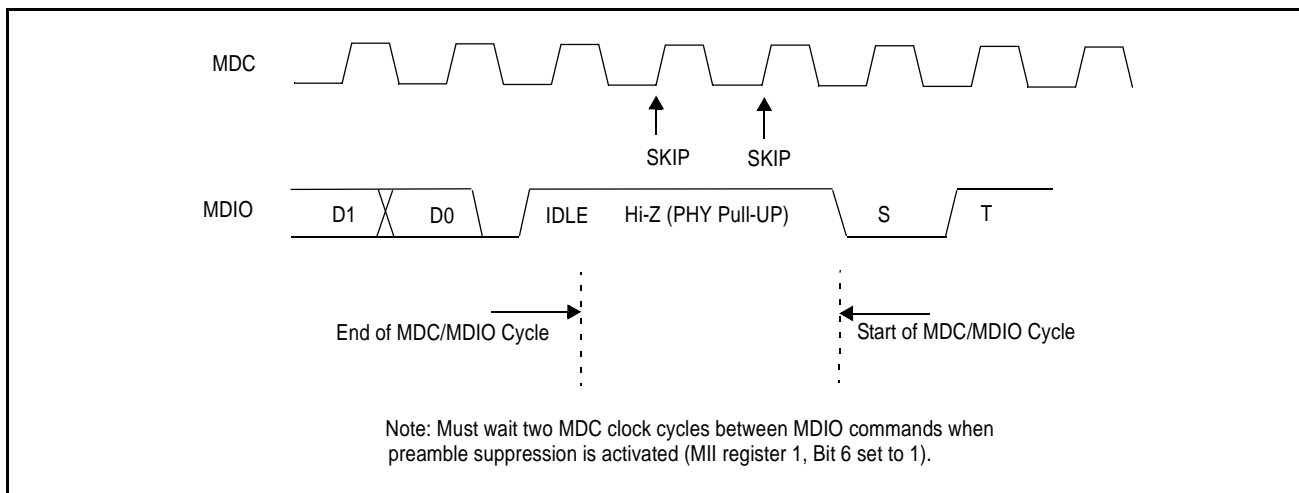


Figure 15: Management Interface Timing (with Preamble Suppression On)

RMII transmit timing parameters are described in Table 50 and Figure 16 illustrates the RMII management transmit timing.

Table 50: RMII Transmit Timing

Parameter	Symbol	Min	Typ	Max	Unit
REF_CLK Cycle Time			20		ns
TXEN, TXER, TXD[1:0] Setup Time to REF_CLK rising	TXEN_SETUP	4			ns
TXEN, TXER, TXD[1:0] Hold Time from REF_CLK rising	TXEN_HOLD	2			ns

Notes:

1. TXD[1:0] provides valid data for each REF_CLK period while TX_EN is asserted.
2. As the REF_CLK frequency is 10 times the data rate in 10Mbps mode, the value on TXD[1:0] is valid so that TXD[1:0] can be sampled every 10th cycle, regardless of the starting cycle within the group, and yield the correct frame data.

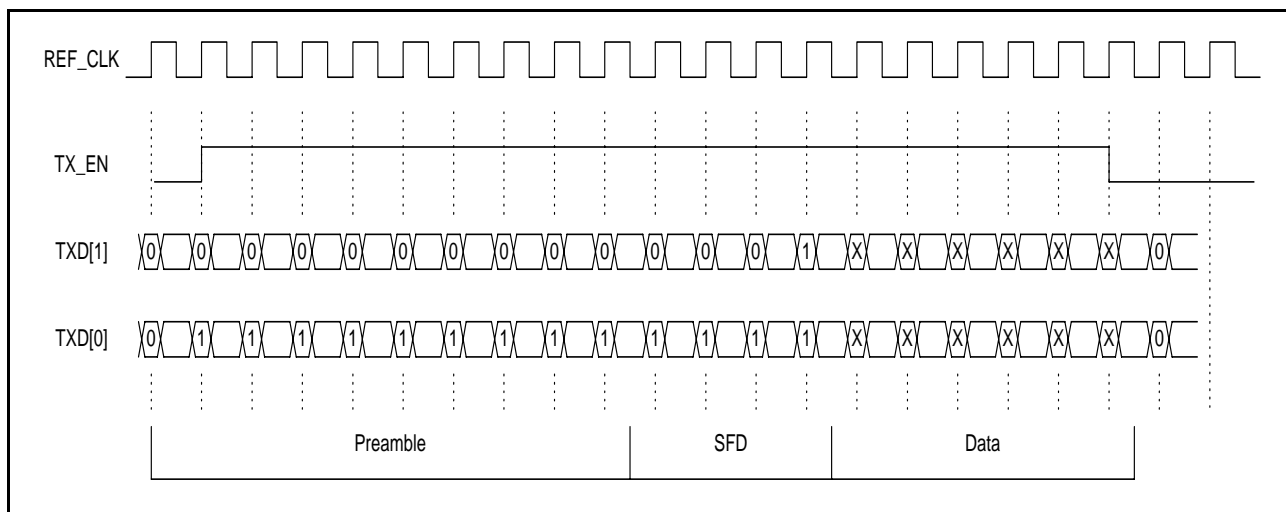


Figure 16: RMII Transmit Packet Timing

RMII receive timing parameters are described in Table 51 and Figure 17 illustrates the RMII management receive timing.

Table 51: RMII Receive Timing

Parameter	Symbol	Min	Typ	Max	Unit
REF_CLK Cycle Time			20		ns
RXD[1:0], RXER, CRS_DV Output delay from REF_CLK Rising		2		16	ns

Notes:

1. As the REF_CLK frequency is 10 times the data rate in 10-Mbps mode, the value on RXD[1:0] is valid so that RXD[1:0] can be sampled every 10th cycle, regardless of the starting cycle within the group, and yield the correct frame data.
2. The receiver accounts for differences between the local REF_CLK and the recovered clock through use of sufficient elasticity buffering.
3. The output delay is with a load of 25 PF, which accommodates a PCB trace length of over 12 inches.



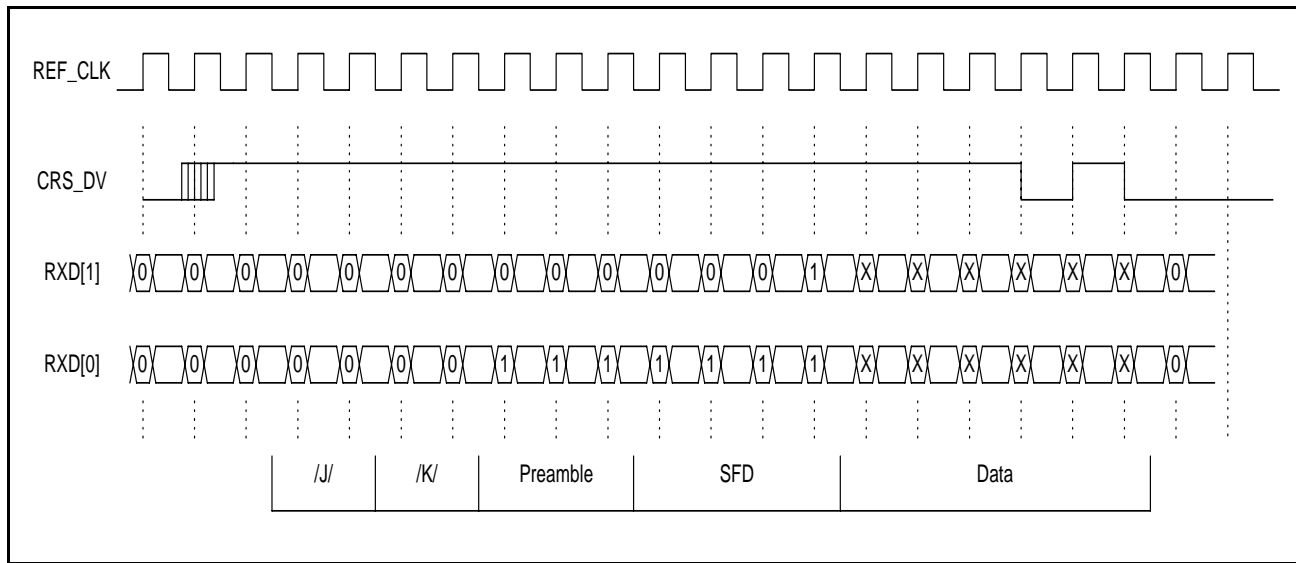


Figure 17: RMI Receive Packet Timing

Table 52 describes the RMI 100BASE-X propagation delay timing parameters, and Table 53 describes the RMI 10BASE-T propagation delay timing parameters.

Table 52: RMI 100BASE-X Propagation Delay Timing

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
TD± after TXEN Assert	TXEN_TDATA		89		ns
TXD to TD± Steady State Delay	TXD_TDATA		95		ns
CRS_DV Assert after RD±	RX_CRSDV		124		ns
CRS_DV Deassert after RD±, premature end	RX_CRSDV		164		ns
CRS_DV Deassert after RD±, valid EOP	RX_CRSDV_EOP		237		ns

Table 53: RMI 10BASE-T Propagation Delay Timing

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
TD± after TXEN Assert (sampled)	TXEN_TDATA		585		ns
CRS_DV Assert after RD±	RX_CRSDV		220		ns



Section 7: Electrical Characteristics

Table 54 provides the absolute maximum ratings for the BCM5220. The recommended operating conditions for the BCM5220 are shown in Table 55. Table 56 on page 71 gives the electrical characteristics of the BCM5220.

Table 54: Absolute Maximum Ratings

Symbol	Parameter		Min	Max	Units
V _{DD}	Supply Voltage	REGDVDD, REGAVDD, OVDD	GND - 0.3	3.60	V
		DVDD, AVDD, BIASVDD	GND - 0.3	2.75	V
V _I	Input Voltage		GND - 0.3	OVDD + 0.3	V
I _I	Input Current			±10	mA
T _{STG}	Storage Temperature		-40	+125	°C

Note: These specifications indicate levels where permanent damage to the device may occur. Functional operation is not guaranteed under these conditions. Operation at absolute maximum conditions for extended periods may adversely affect long-term reliability of the device.

Table 55: Recommended Operating Conditions for BCM5220

Symbol	Parameter	Pin	Operating Mode	Min	Max	units
V _{DD}	Supply Voltage BCM5220	REGDVDD, REGAVDD, OVDD		3.00	3.60	V
		DVDD, AVDD, BIASVDD		2.375	2.625	V
V _{IH}	High-Level Input Voltage	All Digital Inputs		2.0	OVDD	V
V _{IL}	Low-Level Input Voltage	All Digital Inputs			0.8	V
		SD±	100BASE-TX		0.4	V
V _{IDIFF}	Differential Input Voltage	RD±, SD±	100BASE-FX	150		mV
V _{ICM}	Common Mode Input Voltage	RD±	100BASE-TX	1.85	2.05	V
		RD±, SD±	100BASE-FX	1.85	2.05	V
T _A	Ambient Operating Temperature			0	70	°C

Table 56: Electrical Characteristics

Symbol	Parameter	Pins	Conditions	Min	Typ	Max	Units
I _{DD}	Supply Current	AVDD, DVDD, OVDD	100BASE-TX		110		mA
I _{DD}	Supply Current	AVDD, DVDD, OVDD	CLOCK ON		12		mA
	Low Power mode		ENERGY DET ON				
I _{DDQ}	Supply Current Power Off mode	AVDD, DVDD, OVDD	Hardware/Software		3		mA

Table 56: Electrical Characteristics (Cont.)

Symbol	Parameter	Pins	Conditions	Min	Typ	Max	Units
V _{OH}	High-Level Output Voltage	All Digital Outputs	I _{OH} = -12 mA	OVDD-0.5			V
		TD±	driving loaded magnetics module			AVDD+1.5	V
V _{OL}	Low-Level Output Voltage	All Digital Outputs	I _{OL} = 8 mA			0.4	V
		TD±	driving loaded magnetics module	AVDD-1.5			V
V _{ODIFF}	Differential Output Voltage	TD±	100BASE-FX Mode	400			mV
I _I	Input Current	Digital Inputs w/ Pull-Up Resistors	V _I = OVDD			+100	μA
			V _I = DGND			-200	μA
		Digital Inputs w/ Pull-Down Resistors	V _I = OVDD			+200	μA
			V _I = DGND			-100	μA
All other Digital Inputs	DGND ≤ V _I ≤ OVDD			±100	μA		
I _{OZ}	High-Impedance Output Current	All Three-state Outputs	DGND ≤ V _O ≤ OVDD				μA
		All Open-drain Outputs	V _O = OVDD				μA
V _{BIAS}	Bias Voltage	RDAC		1.18		1.30	V



Section 8: Application Example

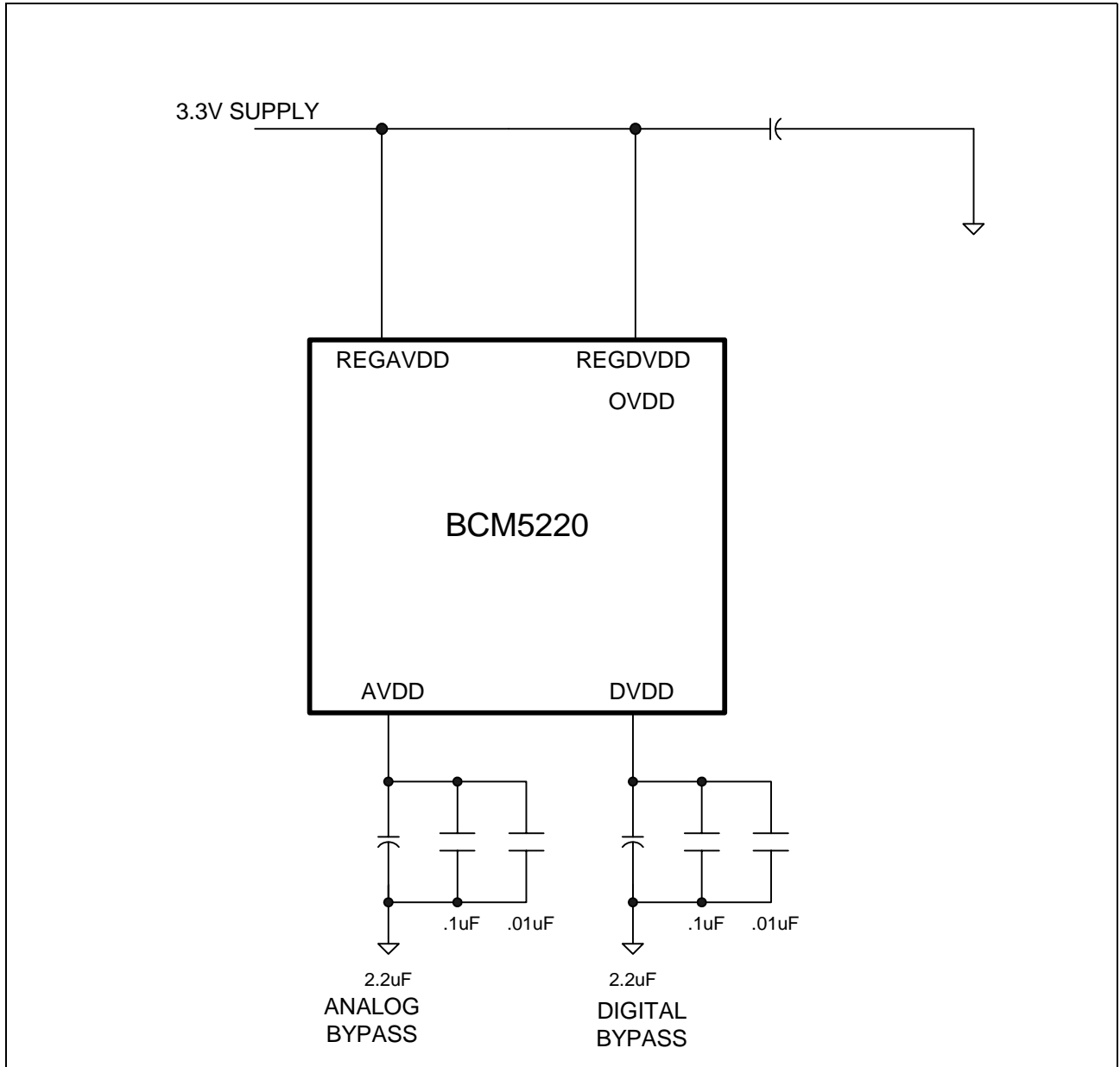


Figure 18: Power Connections BCM5220 (3.3V)

Section 9: Thermal Characteristics

Table 57: θ_{JA} vs. Airflow for the BCM5220KPB (FBGA 64)

AIRFLOW (Feet Per Minute)	0	100	200	400	600
Theta - J_A (°C/W)	35.15	25.57	22.99	20.88	20.30

Theta JC for this package in still air is 21.23 °C/W. The BCM5220KPB is designed and rated for a maximum junction temperature of 125 °C.

Table 58: θ_{JA} vs. Airflow for the BCM5220KPT (64 TQFP)

AIRFLOW (Feet Per Minute)	0	100	200	400	600
Theta - J_A (°C/W)	56.4	51.9	49.9	48.2	47.2

Theta JC for this package in still air is 18.5°C/W. The BCM5220KPT is designed and rated for a maximum junction temperature of 125°C.



Section 10: Mechanical Information

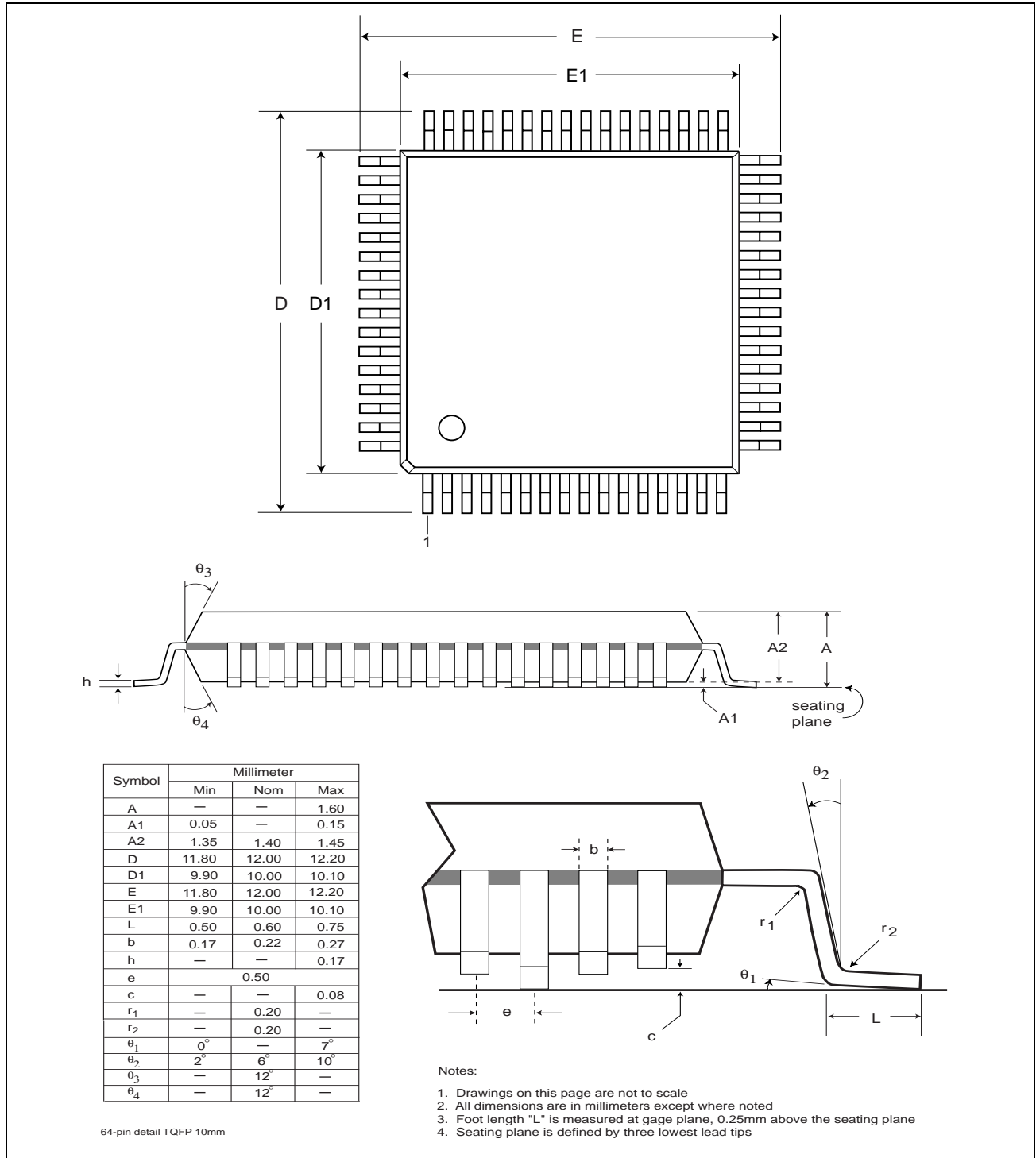


Figure 19: 64-Pin TQFP 10mm Package (BCM5220 KPT)

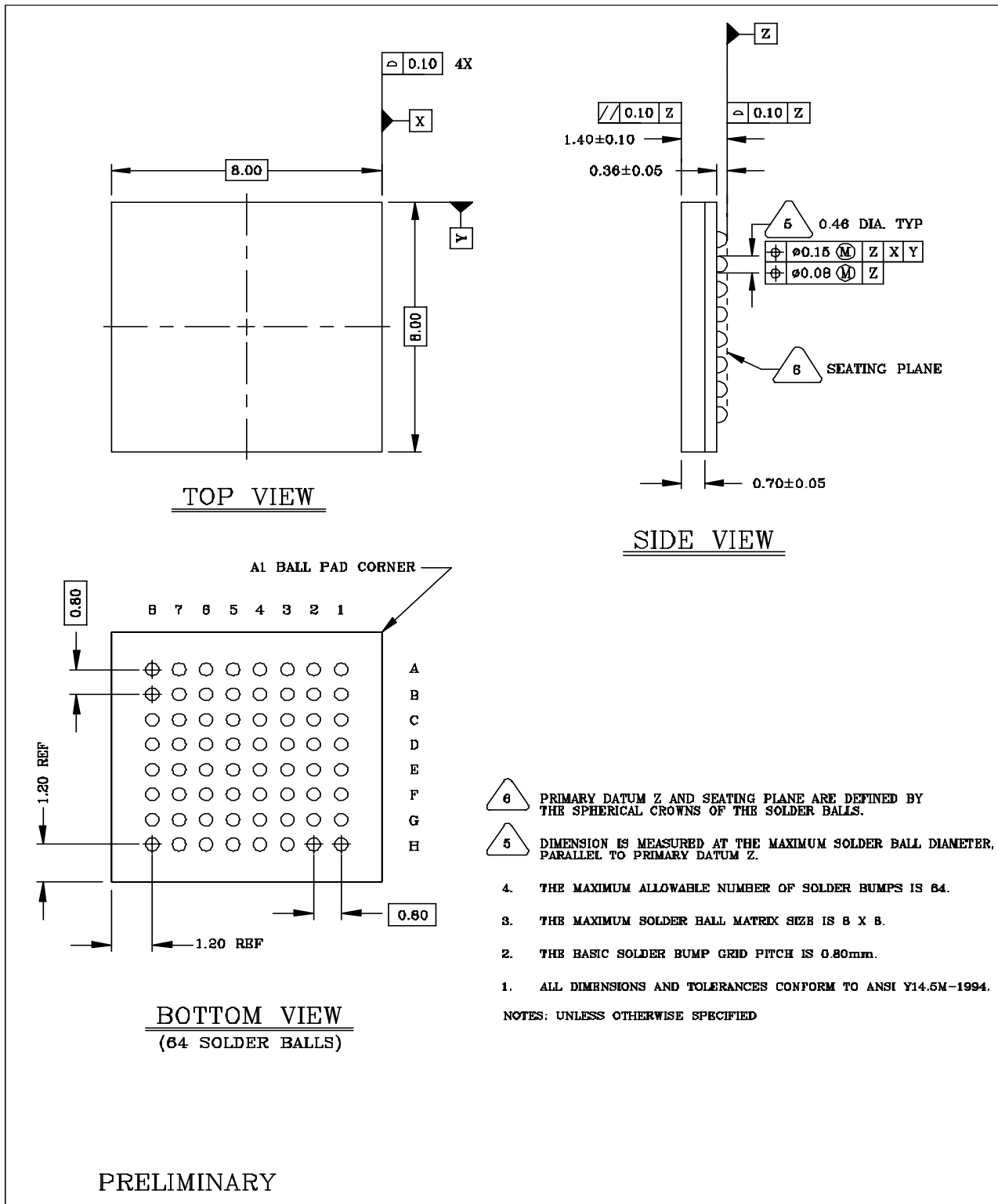


Figure 20: FBGA 64-pin Package, 8 mm x 8 mm (BCM5220 KPB)



Section 11: Ordering Information

<i>Part Number</i>	<i>Package</i>	<i>Ambient Temperature</i>
BCM5220KPT	64-pin TQFP 10 mm package	-40° to 85° C
BCM5220KPB	FBGA 64-pin 8 mm x 8 mm package	-40° to 85° C

Broadcom Corporation

16215 Alton Parkway
P.O. Box 57013
Irvine, CA 92619-7013
Phone: 949-450-8700
Fax: 949-450-8710

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