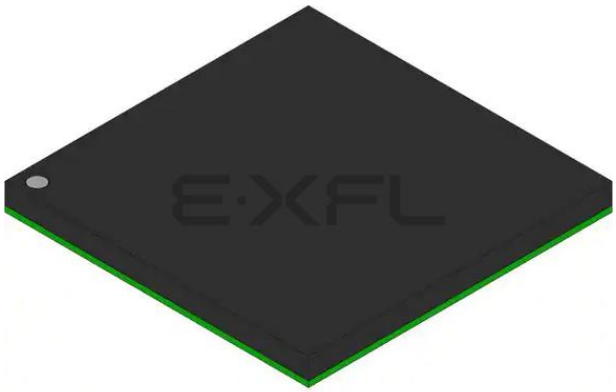

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Understanding Embedded - Microprocessors

Embedded microprocessors are specialized computing chips designed to perform specific tasks within an embedded system. Unlike general-purpose microprocessors found in personal computers, embedded microprocessors are tailored for dedicated functions within larger systems, offering optimized performance, efficiency, and reliability. These microprocessors are integral to the operation of countless electronic devices, providing the computational power necessary for controlling processes, handling data, and managing communications.

Applications of Embedded - Microprocessors

Embedded microprocessors are utilized across a broad spectrum of applications, making them indispensable in

Details	
Product Status	Active
Core Processor	ARM926EJ-S
Number of Cores/Bus Width	1 Core, 32-Bit
Speed	266MHz
Co-Processors/DSP	-
RAM Controllers	SDRAM
Graphics Acceleration	No
Display & Interface Controllers	Keypad, LCD
Ethernet	-
SATA	-
USB	USB 1.x (2)
Voltage - I/O	1.8V, 3.0V
Operating Temperature	-40°C ~ 85°C (TA)
Security Features	-
Package / Case	289-LFBGA
Supplier Device Package	289-PBGA (17x17)
Purchase URL	https://www.e-xfl.com/pro/item?MUrl=&PartUrl=mc9328mx21cvm

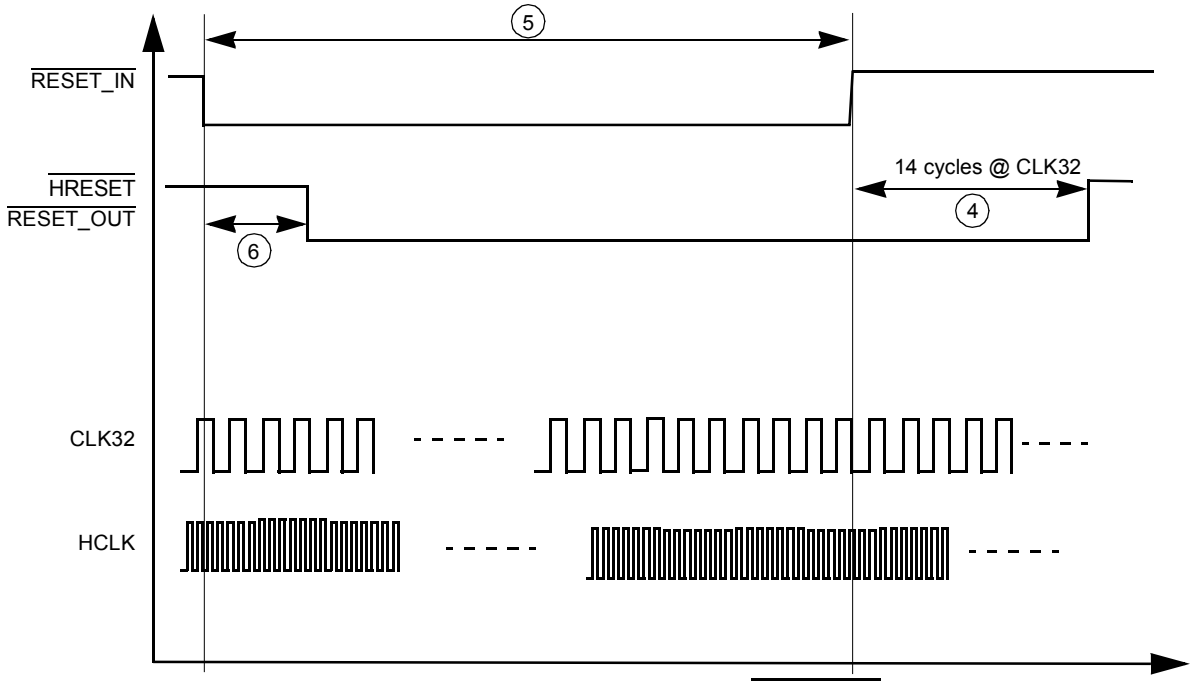


Figure 3. Timing Relationship with $\overline{\text{RESET\_IN}}$

Table 12. Reset Module Timing Parameters

Ref No.	Parameter	1.8 V ± 0.10 V		3.0 V ± 0.30 V		Unit
		Min	Max	Min	Max	
1	Width of input POWER_ON_RESET	800	–	800	–	ms
2	Width of internal $\overline{\text{POWER\_ON\_RESET}}$ (CLK32 at 32 kHz)	300	300	300	300	ms
3	7k to 32k-cycle stretcher for SDRAM reset	7	7	7	7	Cycles of CLK32
4	14k to 32k-cycle stretcher for internal system reset $\overline{\text{HRESERT}}$ and output reset at pin $\overline{\text{RESET\_OUT}}$	14	14	14	14	Cycles of CLK32
5	Width of external hard-reset $\overline{\text{RESET\_IN}}$	4	–	4	–	Cycles of CLK32
6	4k to 32k-cycle qualifier	4	4	4	4	Cycles of CLK32

3.7 External DMA Request and Grant

The External DMA request is an active low signal to be used by devices external to i.MX21 processor to request the DMAC for data transfer.

After assertion of External DMA request the DMA burst will start when the channel on which the External request is the source (as per the RSSR settings) becomes the current highest priority channel. The external device using the External DMA request should keep its request asserted until it is serviced by the DMAC. One External DMA request will initiate one DMA burst.

The output External Grant signal from the DMAC is an active-low signal.When the following conditions are true, the External DMA Grant signal is asserted with the initiation of the DMA burst.

- The DMA channel for which the DMA burst is ongoing has request source as external DMA Request
  (as per source select register setting).
- REN and CEN bit of this channel are set.
- External DMA Request is asserted.

After the grant is asserted, the External DMA request will not be sampled until completion of the DMA burst. As the external request is synchronized, the request synchronization will not be done during this period. The priority of the external request becomes low for the next consecutive burst, if another DMA request signal is asserted.

Worst case—that is, the smallest burst (1 byte read/write) timing diagrams are shown in Figure 4 and Figure 5. Minimum and maximum timings for the External request and External grant signals are present in Table 13.

Figure 4 shows the minimum time for which the External Grant signal remains asserted when an External DMA request is de-asserted immediately after sensing grant signal active.

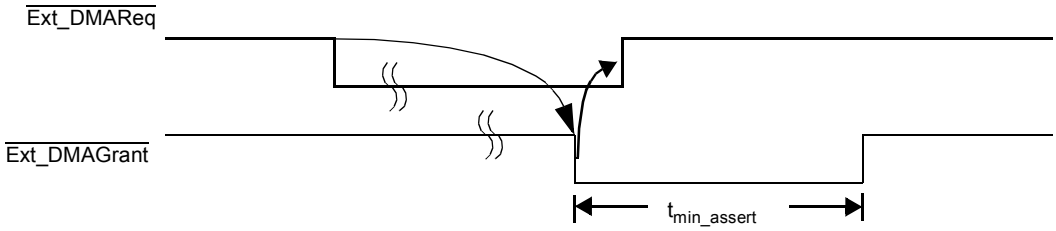
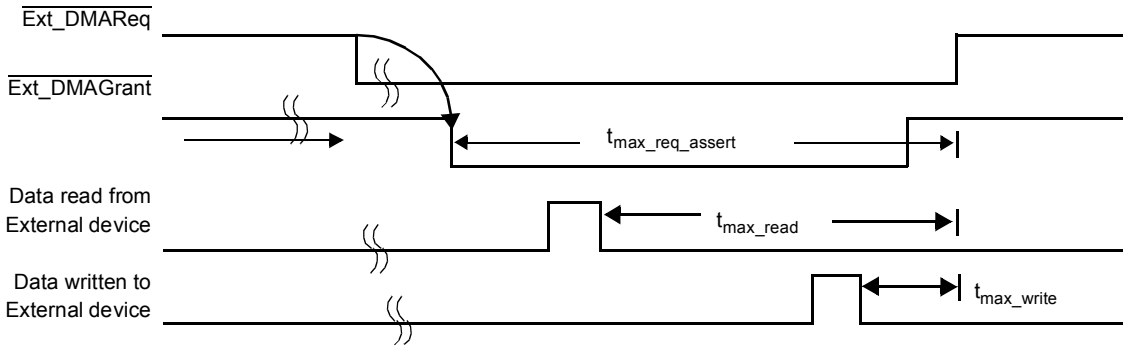


Figure 4. Assertion of DMA External Grant Signal

Figure 5 shows the safe maximum time for which External DMA request can be kept asserted, after sensing grant signal active such that a new burst is not initiated.



NOTE: Assuming in worst case the data is read/written from/to External device as per the above waveform.

Figure 5. Safe Maximum Timings for External Request De-Assertion

Table 13. DMA External Request and Grant Timing Parameters

Parameter	Description	3.0 V		1.8 V		Unit
		WCS	BCS	WCS	BCS	
t_{min_assert}	Minimum assertion time of External Grant signal	8 hclk + 8.6	8 hclk + 2.74	8 hclk + 7.17	8 hclk + 3.25	ns
$t_{max\_req\_assert}$	Maximum External request assertion time after assertion of Grant signal	9 hclk - 20.66	9 hclk - 6.7	9 hclk - 17.96	9 hclk - 8.16	ns
t_{max_read}	Maximum External request assertion time after first read completion	8 hclk - 6.21	8 hclk - 0.77	8 hclk - 5.84	8 hclk - 0.66	ns
t_{max_write}	Maximum External request assertion time after completion of first write	3 hclk - 15.87	3 hclk - 8.83	3 hclk - 15.9	3 hclk - 9.12	ns

3.8 BMI Interface Timing Diagram

3.8.1 Connecting BMI to ATI MMD Devices

3.8.1.1 ATI MMD Devices Drive the BMI_CLK/CS

In this mode MMD_MODE_SEL bit is set and MMD_CLKOUT bit is cleared. $\overline{\text{BMI\_WRITE}}$ and BMI_CLK/CS are input signals to BMI driving by ATI MMD chip set. Output signal BMI_READ_REQ can be used as interrupt signal to inform MMD that data is ready in BMI TxFIFO for read access. MMD can write data to BMI RxFIFO anytime as CPU or DMA can move data out from RxFIFO much faster than the BMI interface. Overflow interrupt is generated if RxFIFO overflow is detected. Once this happens, the new coming data is ignored.

3.8.1.1.1 MMD Read BMI Timing

Figure 6 shows the MMD read BMI timing when the MMD drives clock.

On each rising edge of BMI_CLK/CS BMI checks the $\overline{\text{BMI\_WRITE}}$ logic level to determine if the current cycle is a read cycle. It puts data into the data bus and enables the data out on the rising edge of BMI_CLK/CS if BMI_WRITE is logic high. The BMI_READ_REQ is negated one hclk cycle after the BMI_CLK/CS rising edge of last data read. The MMD cannot issues read command when BMI_READ_REQ is low (no data in TxFIFO).

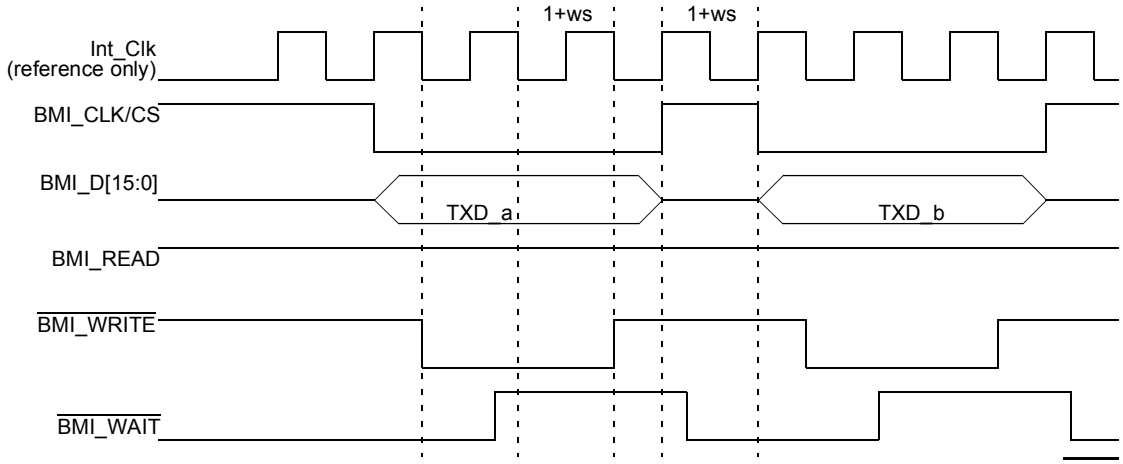


Figure 12. Memory Interface Master Mode, BMI Write to External Slave Device Timing with Wait Signal (MMD_MODE_SEL=0, MASTER_MODE_SEL=1,WAIT=1)

Figure 13 shows the BMI read timing when the WAIT bit is set. As write timing, when the BMI_READ is asserted, the BMI will detect the BMI_WAIT signal on every falling edge of the Int_Clk. When it detected the high level of the BMI_WAIT, the BMI_READ will be negated after 1+WS Int_Clk period. If the BMI_WAIT is always high or already high before BMI_READ is asserted, this timing will same as without WAIT signal. So the BMI_READ will be asserted at least for 1+WS Int_Clk period.

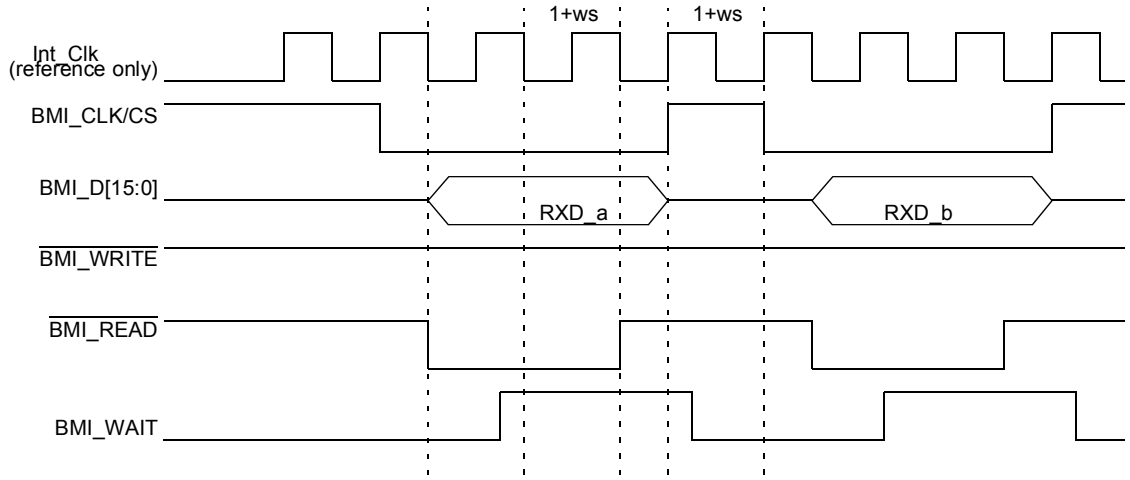


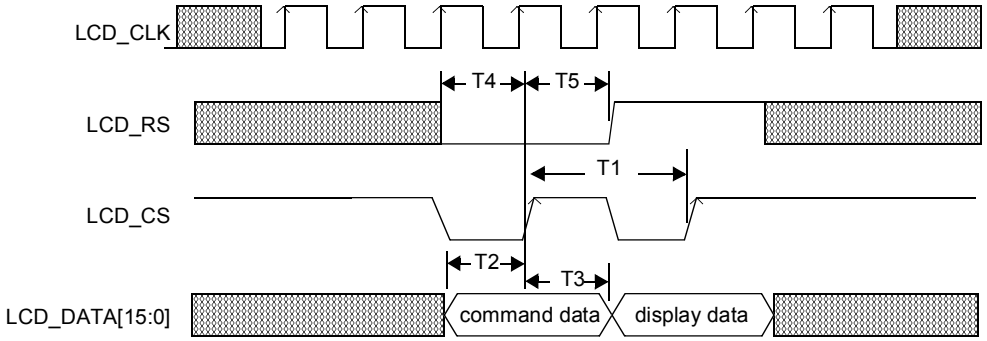
Figure 13. Memory Interface Master Mode, BMI Read to External Slave Device Timing with Wait Signal (MMD_MODE_SEL=0, MASTER_MODE_SEL=1,WAIT=1)

3.9 CSPI Timing Diagrams

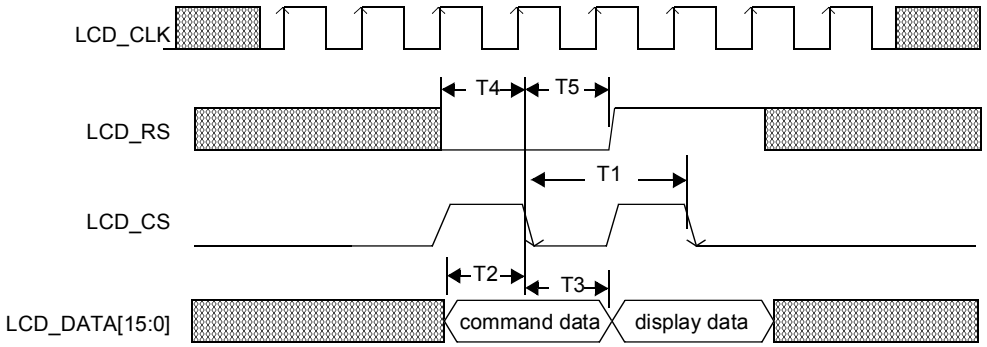
To use the internal transmit (TX) and receive (RX) data FIFOs when the CSPI1 module is configured as a master, two control signals are used for data transfer rate control: the SS signal (output) and the SPI_RDY signal (input). The SPI 1 Sample Period Control Register (PERIODREG1) and the SPI 2 Sample Period Control Register (PERIODREG2) can also be programmed to a fixed data transfer rate for either CSPI1 or CSPI2. When the CSPI1 module is configured as a slave, the user can configure the SPI 1 Control Register (CONTROLREG1) to match the external CSPI master's timing. In this configuration, SS

Table 24. SLCDC Serial Transfer Timing

Symbol	Description	Minimum	Maximum	Unit
T1	Pixel clock period	42	962	ns
T2	Chip select setup time	5	–	ns
T3	Chip select hold time	5	–	ns
T4	Data setup time	5	–	ns
T4	Data hold time	5	–	ns
T6	Register select setup time	5	–	ns
T7	Register select hold time	5	–	ns



CSPOL = 0



CSPOL = 1

Figure 24. SLCDC Parallel Transfers Timing

Table 25. SLCDC Parallel Transfers Timing

Symbol	Description	Minimum	Maximum	Unit
T1	Pixel clock period	23	962	ns
T2	Data setup time	5	–	ns
T3	Data hold time	5	–	ns
T4	Register select setup time	5	–	ns
T5	Register select hold time	5	–	ns

3.12.1 Command Response Timing on MMC/SD Bus

The card identification and card operation conditions timing are processed in open-drain mode. The card response to the host command starts after exactly N_{ID} clock cycles. For the card address assignment, SET_RCA is also processed in the open-drain mode. The minimum delay between the host command and card response is NCR clock cycles as illustrated in Figure 26. The symbols for Figure 26 through Figure 30 are defined in Table 27.

Table 27. State Signal Parameters for Figure 26 through Figure 30

Card Active		Host Active	
Symbol	**Definition**	**Symbol**	**Definition**
Z	High impedance state	S	Start bit (0)
D	Data bits	T	Transmitter bit (Host = 1, Card = 0)
*	Repetition	P	One-cycle pull-up (1)
CRC	Cyclic redundancy check bits (7 bits)	E	End bit (1)

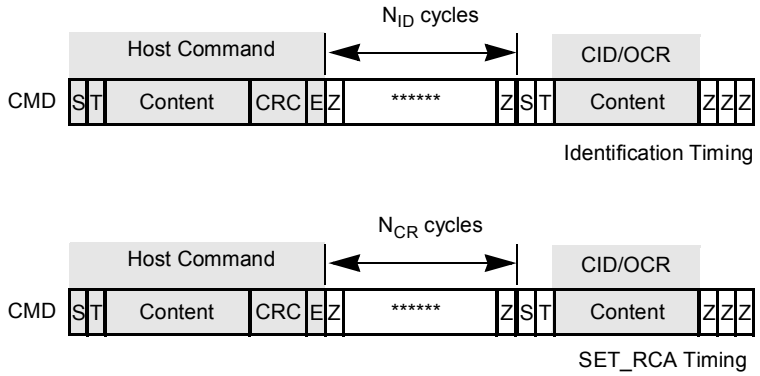


Figure 26. Timing Diagrams at Identification Mode

After a card receives its RCA, it switches to data transfer mode. As shown on the first diagram in Figure 27, SD_CMD lines in this mode are driven with push-pull drivers. The command is followed by a period of two Z bits (allowing time for direction switching on the bus) and then by P bits pushed up by the responding card. The other two diagrams show the separating periods N_{RC} and N_{CC}.

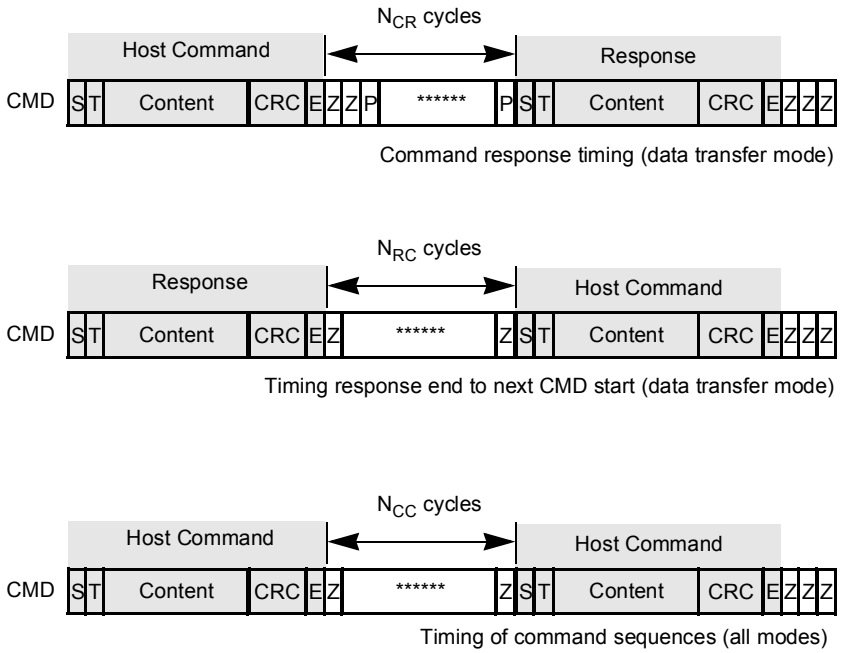


Figure 27. Timing Diagrams at Data Transfer Mode

Figure 28 shows basic read operation timing. In a read operation, the sequence starts with a single block read command (which specifies the start address in the argument field). The response is sent on the SD_CMD lines as usual. Data transmission from the card starts after the access time delay N_{AC}, beginning from the last bit of the read command. If the system is in multiple block read mode, the card sends a continuous flow of data blocks with distance N_{AC} until the card sees a stop transmission command. The data stops two clock cycles after the end bit of the stop command.

Table 29. NFC Target Timing Parameters[1,2]

ID	Parameter	Symbol	Relationship to NFC Clock Period (T)		NFC Clock 22.17 MHz T = 45 ns		NFC Clock 33.25 MHz T = 30 ns		Unit
			Min	Max	Min	Max	Min	Max	
NF1	NFCLE Setup Time	tCLS	T	–	45	–	30	–	ns
NF2	NFCLE Hold Time	tCLH	T	–	45	–	30	–	ns
NF3	$\overline{\text{NFCE}}$ Setup Time	tCS	T	–	45	–	30	–	ns
NF4	$\overline{\text{NFCE}}$ Hold Time	tCH	T	–	45	–	30	–	ns
NF5	$\overline{\text{NF\_WP}}$ Pulse Width	tWP	T	–	45	–	30	–	ns
NF6	NFALE Setup Time	tALS	T	–	45	–	30	–	ns
NF7	NFALE Hold Time	tALH	T	–	45	–	30	–	ns
NF8	Data Setup Time	tDS	T	–	45	–	30	–	ns
NF9	Data Hold Time	tDH	T	–	45	–	30	–	ns
NF10	Write Cycle Time	tWC	2T	–	90	–	60	–	ns
NF11	$\overline{\text{NFWE}}$ Hold Time	tWH	T	–	45	–	30	–	ns
NF12	Ready to $\overline{\text{NFRE}}$ Low	tRR	4T	–	180	–	120	–	ns
NF13	$\overline{\text{NFRE}}$ Pulse Width	tRP	1.5T	–	67.5	–	45	–	ns
NF14	READ Cycle Time	tRC	2T	–	90	–	60	–	ns
NF15	$\overline{\text{NFRE}}$ High Hold Time	tREH	0.5T	–	22.5	–	15	–	ns
NF16	Data Setup on READ	tDSR	15	–	15	–	15	–	ns
NF17	Data Hold on READ	tDHR	0	–	0	–	0	–	ns

1. High is defined as 80% of signal value and low is defined as 20% of signal value. All timings are listed according to this NFC clock frequency (multiples of NFC clock period) except NF16, which is not NFC clock related.
2. The read data is generated by the NAND Flash device and sampled with the internal NFC clock.

3.14 Pulse-Width Modulator

The PWM can be programmed to select one of two clock signals as its source frequency. The selected clock signal is passed through a divider and a prescaler before being input to the counter. The output is available at the pulse-width modulator output (PWMO) external pin.

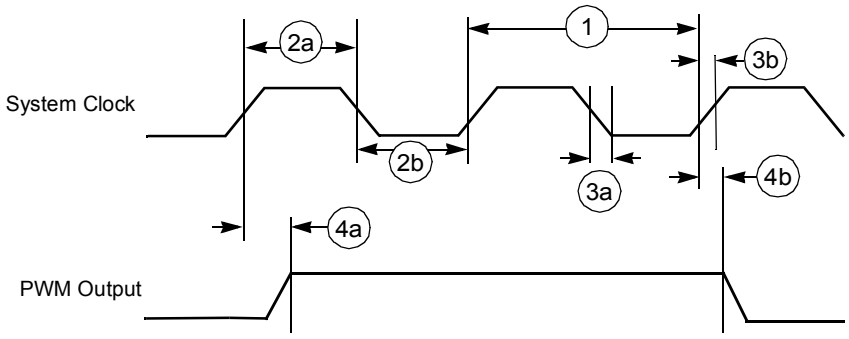


Figure 37. PWM Output Timing Diagram

Table 30. PWM Output Timing Parameters

Ref No.	Parameter	1.8 V ± 0.1 V		3.0 V ± 0.3 V		Unit
		Minimum	Maximum	Minimum	Maximum	
1	System CLK frequency	0	45	0	45	MHz
2a	Clock high time	12.29	–	12.29	–	ns
2b	Clock low time	9.91	–	9.91	–	ns
3a	Clock fall time	–	0.5	–	0.5	ns
3b	Clock ise time r	–	0.5	–	0.5	ns
4a	Output delay time	9.37	–	3.61	–	ns
4b	Output setup time	8.71	–	3.03	–	ns

Table 34. SSI to SAP Ports Timing Parameters (Continued)

Ref No.	Parameter	1.8 V ± 0.1 V		3.0 V ± 0.3 V		Unit
		Minimum	Maximum	Minimum	Maximum	
Synchronous Internal Clock Operation (SAP Ports)						
31	SRXD setup before (Tx) CK falling	23.00	–	21.41	–	ns
32	SRXD hold after (Tx) CK falling	0	–	0	–	ns
Synchronous External Clock Operation (SAP Ports)						
33	SRXD setup before (Tx) CK falling	1.20	–	0.88	–	ns
34	SRXD hold after (Tx) CK falling	0	–	0	–	ns

1. All the timings for the SSI are given for a non-inverted serial clock polarity (TSCKP/RSCKP = 0) and a non-inverted frame sync (TFSI/RFSI = 0). If the polarity of the clock and/or the frame sync have been inverted, all the timing remains valid by inverting the clock signal STCK/SRCK and/or the frame sync STFS/SRFS shown in the tables and in the figures.

Table 35. SSI to SSI1 Ports Timing Parameters

Ref No.	Parameter	1.8 V ± 0.1 V		3.0 V ± 0.3 V		Unit
		Minimum	Maximum	Minimum	Maximum	
Internal Clock Operation[1] (SSI1 Ports)						
1	(Tx/Rx) CK clock period[1] 9	0.91	–	90.91	–	ns
2	(Tx) CK high to FS (bl) high	-0.68	-0.15	-0.68	-0.15	ns
3	(Rx) CK high to FS (bl) high	-0.96	-0.27	-0.96	-0.27	ns
4	(Tx) CK high to FS (bl) low	-0.68	-0.15	-0.68	-0.15	ns
5	(Rx) CK high to FS (bl) low	-0.96	-0.27	-0.96	-0.27	ns
6	(Tx) CK high to FS (wl) high	-0.68	-0.15	-0.68	-0.15	ns
7	(Rx) CK high to FS (wl) high	-0.96	-0.27	-0.96	-0.27	ns
8	(Tx) CK high to FS (wl) low	-0.68	-0.15	-0.68	-0.15	ns
9	(Rx) CK high to FS (wl) low	-0.96	-0.27	-0.96	-0.27	ns
10	(Tx) CK high to STXD valid from high impedance	-1.68	-0.36	-1.68	-0.36	ns
11a	(Tx) CK high to STXD high	-1.68	-0.36	-1.68	-0.36	ns
11b	(Tx) CK high to STXD low	-1.68	-0.36	-1.68	-0.36	ns
12	(Tx) CK high to STXD high impedance	-1.58	-0.31	-1.58	-0.31	ns
13	SRXD setup time before (Rx) CK low	20.41	–	20.41	–	ns
14	SRXD hold time after (Rx) CK low	0	–	0	–	ns
External Clock Operation (SSI1 Ports)						
15	(Tx/Rx) CK clock period[1] 9	0.91	–	90.91	–	ns
16	(Tx/Rx) CK clock high period	36.36	–	36.36	–	ns
17	(Tx/Rx) CK clock low period	36.36	–	36.36	–	ns
18	(Tx) CK high to FS (bl) high	10.22	17.63	8.82	16.24	ns
19	(Rx) CK high to FS (bl) high	10.79	19.67	9.39	18.28	ns

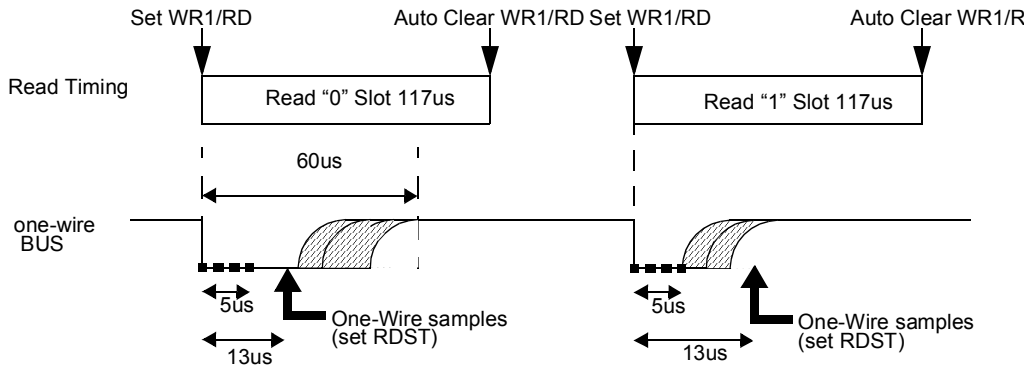


Figure 49. Read Timing

The precision of the generated clock is very important to get a proper behavior of the one-wire module. This module is based on a state machine which undertakes actions at defined times.

Table 38. System Timing Requirements

Times	Values (Microsec)	Minimum (Microsec)	Maximum (microsec)	Absolute Precision	Relative Precision
RSTL	511	480	–	31	0.0645
PST	68	60	75	7	0.1
RSTH	512	480	–	32	0.0645
LOW0	100	60	120	20	0.2
LOWR	5	1	15	4	0.8
READ_sample	13	–	15	2	0.15

The most stringent constraint is 0.0645 as a relative time imprecision.

The time relative precision is directly derived from the frequency of the derivative clock (f):

Time relative precision = 1/f -1 = divider/clock (MHz) - 1

The Figure 39 gathers relative time precision for different main clock frequencies.

Table 39. System Clock Requirements

Main Clock Frequency (MHz)	13	16.8	19.44
Clock divide ratio	13	17	19
Generated frequency (MHz)	1	0.9882	1.023
Relative time imprecision	0	0.0117	0.023

This shows that the user should take care of the main clock frequency when using the one-wire module. If the main clock is an exact integer multiple of 1 MHz, then the generated frequency will be exactly 1 MHz.

NOTE

A main clock frequency below 10 MHz might cause a misbehavior of the module.

3.18 USB On-The-Go

Four types of data transfer modes exist for the USB module: control transfers, bulk transfers, isochronous transfers and interrupt transfers. From the perspective of the USB module, the interrupt transfer type is identical to the bulk data transfer mode, and no additional hardware is supplied to support it. This section covers the transfer modes and how they work from the ground up.

Data moves across the USB in packets. Groups of packets are combined to form data transfers. The same packet transfer mechanism applies to bulk, interrupt, and control transfers. Isochronous data is also moved in the form of packets, but because isochronous pipes are given a fixed portion of the USB bandwidth at all times, there is no end-of-transfer.

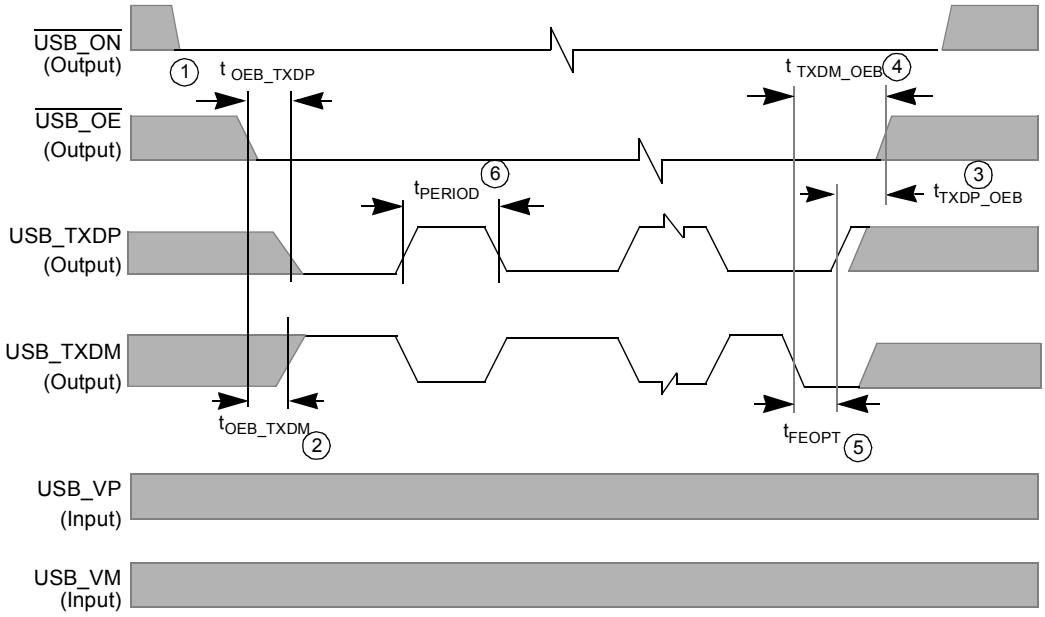


Figure 50. USB Timing Diagram for Data Transfer to USB Transceiver (TX)

Table 40. USB Timing Parameters for Data Transfer to USB Transceiver (TX)

Ref No.	Parameter	3.0 V ± 0.3 V		Unit
		Minimum	Maximum	
1	t_{OEB_TXDP}; $\overline{USBD\_OE}$ active to USBD_TXDP low	83.14	83.47	ns
2	t_{OEB_TXDM}; $\overline{USBD\_OE}$ active to USBD_TXDM high	81.55	81.98	ns
3	t_{TXDP_OEB}; USBD_TXDP high to $\overline{USBD\_OE}$ deactivated	83.54	83.8	ns
4	t_{TXDM_OEB}; USBD_TXDM low to $\overline{USBD\_OE}$ deactivated (includes SE0)	248.9	249.13	ns
5	t_{FEOPT}; SE0 interval of EOP	160	175	ns
6	t_{PERIOD}; Data transfer rate	11.97	12.03	Mb/s

3.19.1 EIM External Bus Timing Diagrams

The following timing diagrams show the timing of accesses to memory or a peripheral.

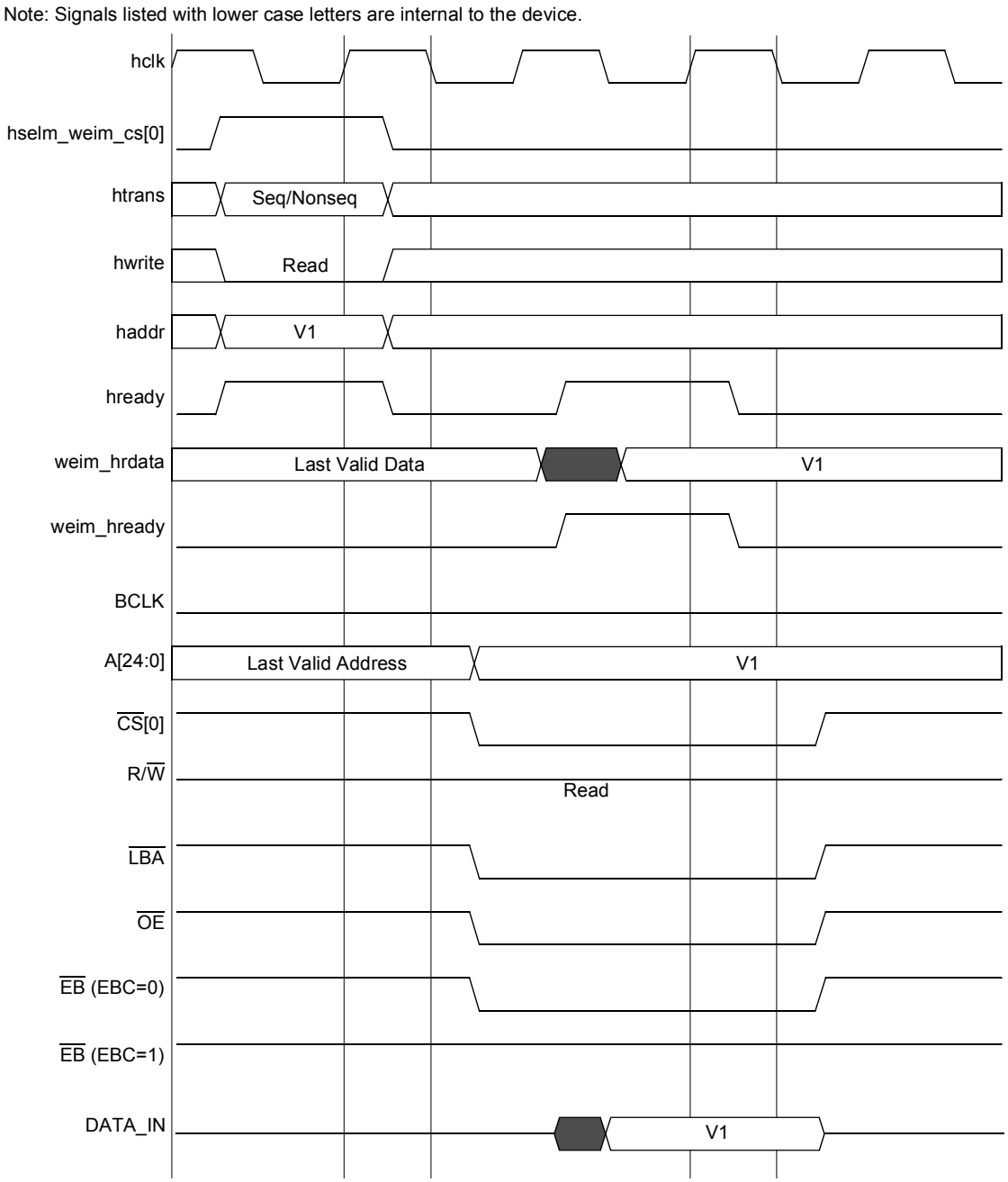


Figure 54. WSC = 1, A.HALF/E.HALF

Note: Signals listed with lower case letters are internal to the device.

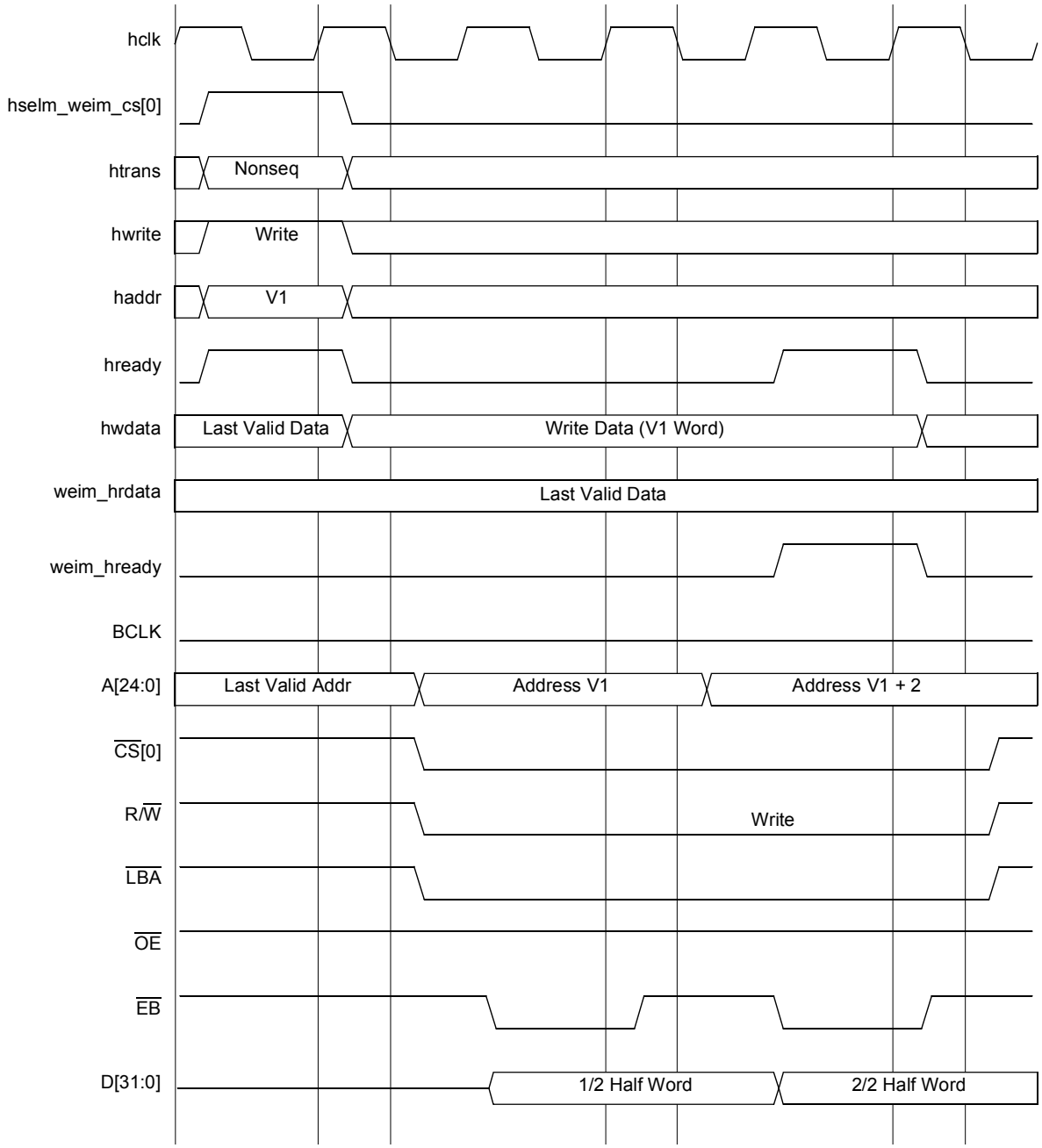


Figure 57. WSC = 1, WEA = 1, WEN = 1, A.WORD/E.HALF

Note: Signals listed with lower case letters are internal to the device.

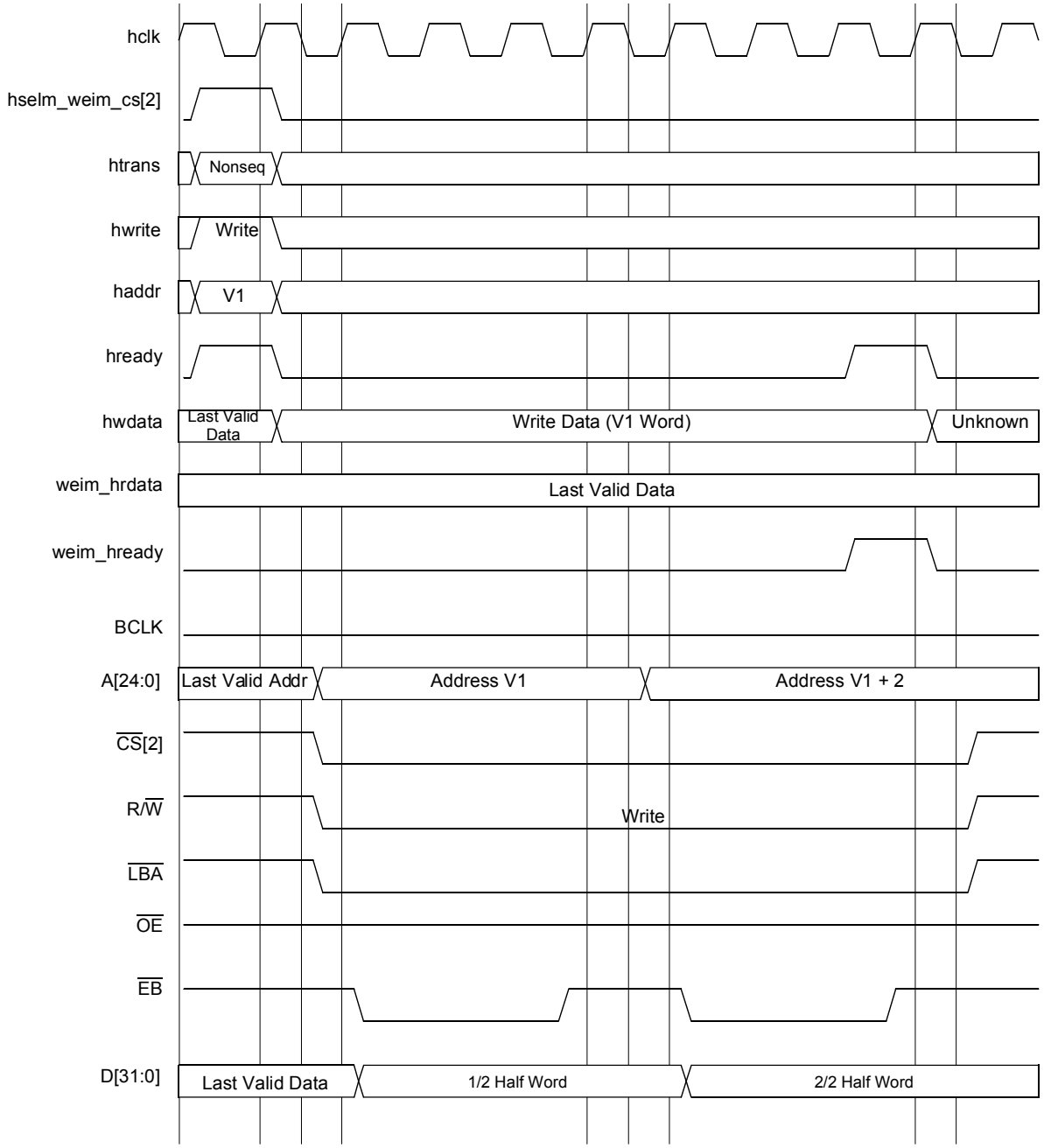


Figure 64. WSC = 2, WWS = 1, WEA = 1, WEN = 2, A.WORD/E.HALF

Note: Signals listed with lower case letters are internal to the device.

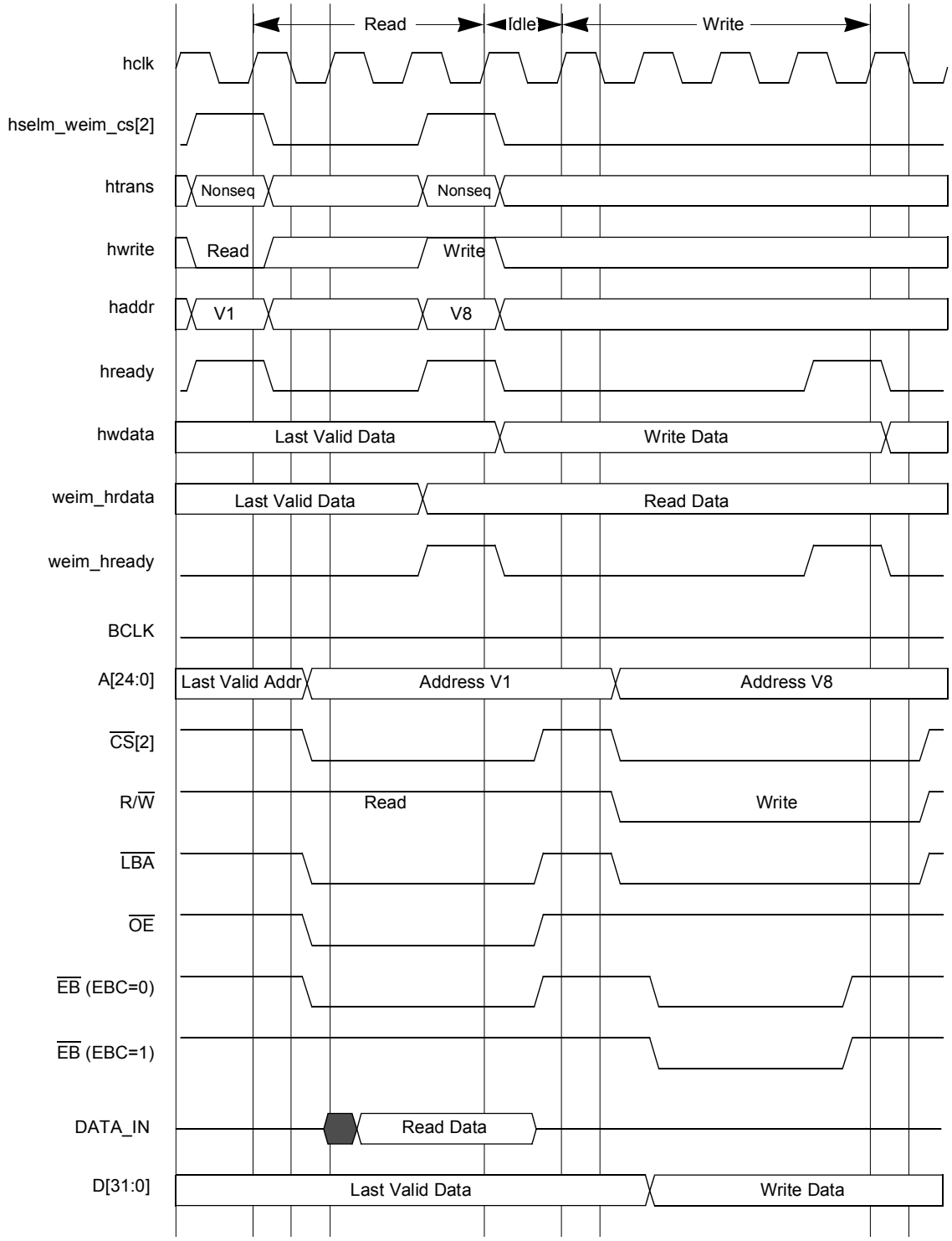


Figure 67. WSC = 2, WWS = 1, WEA = 1, WEN = 2, EDC = 1, A.HALF/E.HALF

Note: Signals listed with lower case letters are internal to the device.

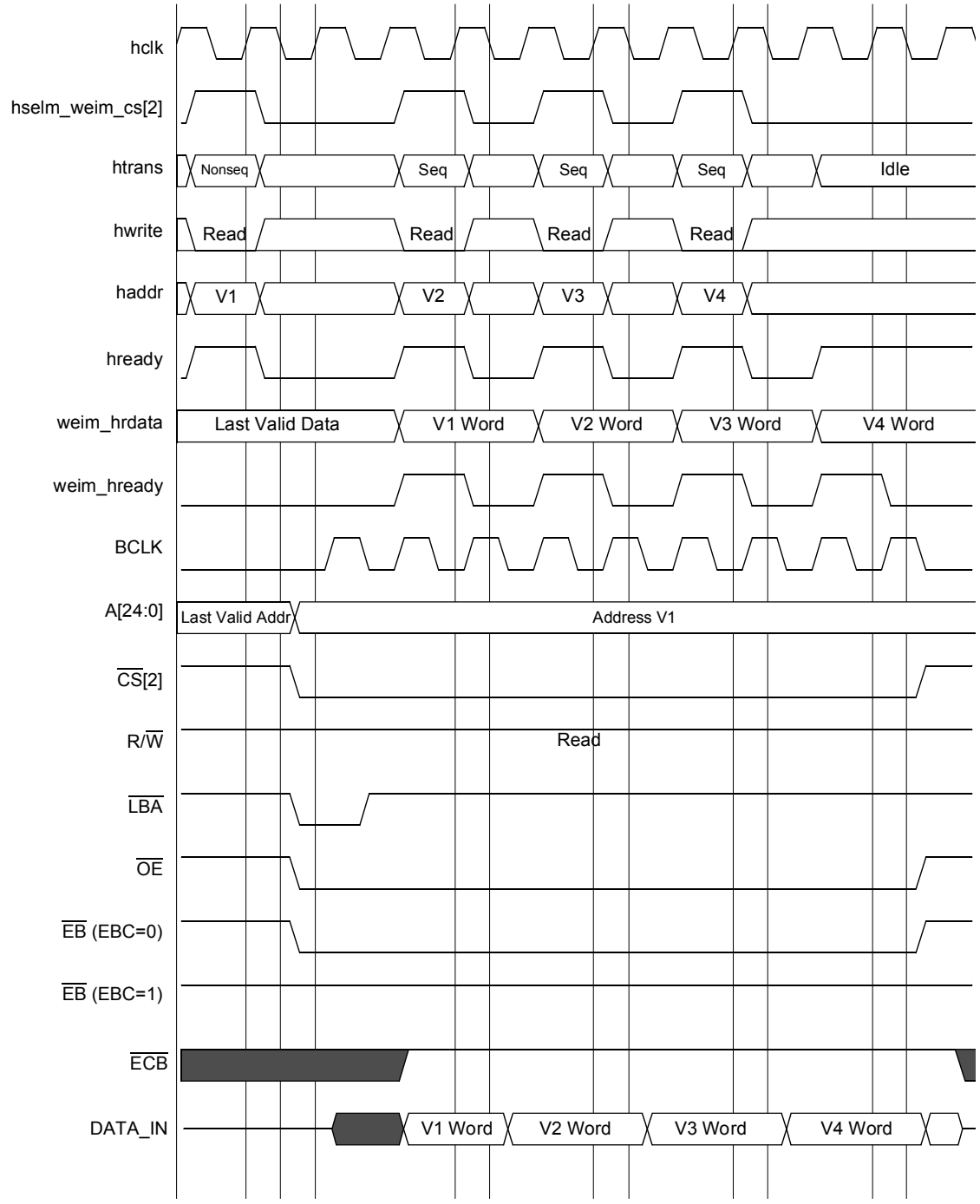


Figure 73. WSC = 2, SYNC = 1, DOL = [1/0], A.WORD/E.WORD

3.21 I²C Module

The I²C communication protocol consists of seven elements: START, Data Source/Recipient, Data Direction, Slave Acknowledge, Data, Data Acknowledge, and STOP.

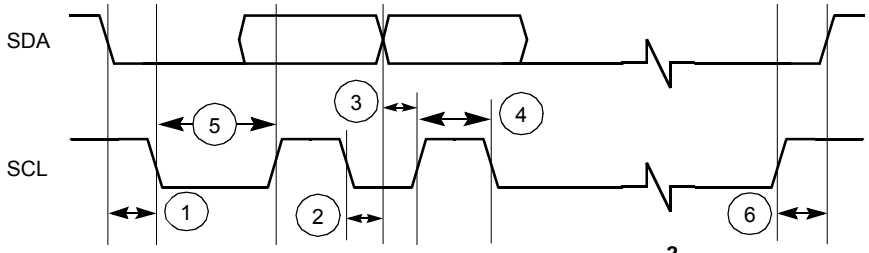


Figure 80. Definition of Bus Timing for I²C

Table 44. I²C Bus Timing Parameters

Ref No.	Parameter	1.8 V ± 0.1 V		3.0 V ± 0.3 V		Unit
		Minimum	Maximum	Minimum	Maximum	
	SCL Clock Frequency	0	100	0	100	kHz
1	Hold time (repeated) START condition	114.8	–	111.1	–	ns
2	Data hold time	0	69.7	0	72.3	ns
3	Data setup time	3.1	–	1.76	–	ns
4	HIGH period of the SCL clock	69.7	–	68.3	–	ns
5	LOW period of the SCL clock	336.4	–	335.1	–	ns
6	Setup time for STOP condition	110.5	–	111.1	–	ns

3.22 CMOS Sensor Interface

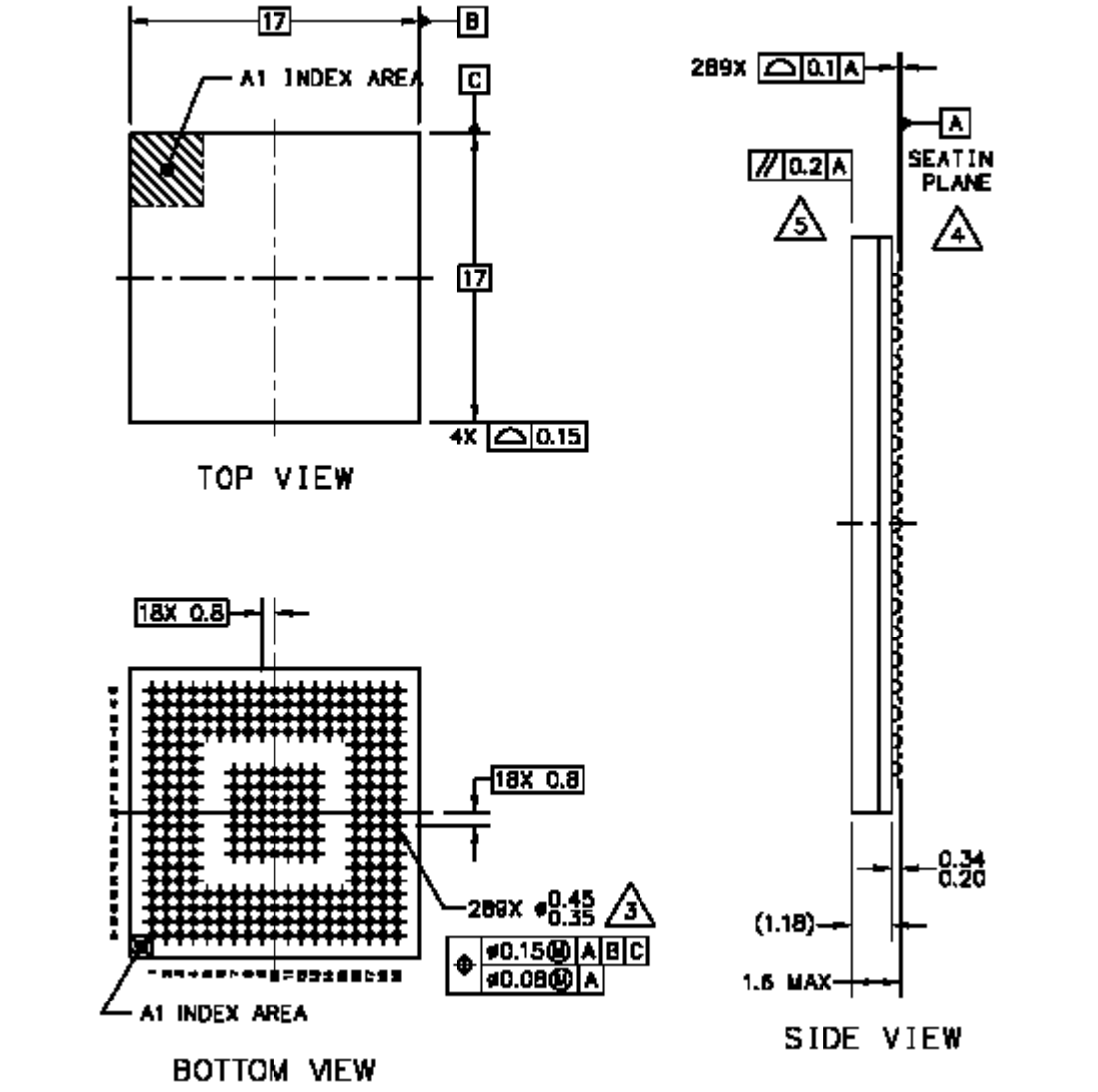
The CSI module consists of a control register to configure the interface timing, a control register for statistic data generation, a status register, interface logic, a 32 × 32 image data receive FIFO, and a 16 × 32 statistic data FIFO.

3.22.1 Gated Clock Mode

Figure 81 shows the timing diagram when the CMOS sensor output data is configured for negative edge and the CSI is programmed to received data on the positive edge. Figure 82 shows the timing diagram when the CMOS sensor output data is configured for positive edge and the CSI is programmed to received data in negative edge. The parameters for the timing diagrams are listed in Table 45. The formula for calculating the pixel clock rise and fall time is located in Section 3.22.3, “Calculation of Pixel Clock Rise/ Fall Time.”

4.2 MAPBGA Package Dimensions

Figure 86 illustrates the MAPBGA 17 mm × 17 mm × 1.45 mm package, which has 0.8 mm spacing between the pads.



NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. DATUM A, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.

Figure 86. i.MX21 MAPBGA Mechanical Drawing

5 Document Revision History

Table 48 provides the document changes for the MC9328MX21 Rev. 3.4.

Table 48. Document Revision History

Location	Description of Change
Table 30 on page 46	Updated the table by removing the table footnote
Table 1 on page 3	Added VM and CVM devices.
Table 7 on page 16	Updated Sleep Current values.
Table 1 on page 4	Added a part number MC9328MX21CJM and a footnote.