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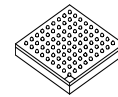
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## MSC7116



MAP-BGA-400  
17 mm × 17 mm

### Low-Cost 16-bit DSP with DDR Controller and 10/100 Mbps Ethernet MAC

- StarCore® SC1400 DSP extended core with one SC1400 DSP core, 192 Kbyte of internal SRAM M1 memory, 16 way 16 Kbyte instruction cache (ICache), four-entry write buffer, programmable interrupt controller (PIC), and low-power Wait and Stop processing modes.
- 192 Kbyte M2 memory for critical data and temporary data buffering.
- 8 Kbyte boot ROM.
- AHB-Lite crossbar switch that allows parallel data transfers between four master ports and six slave ports, where each port connects to an AHB-Lite bus; fixed or round robin priority programmable at each slave port; programmable bus parking at each slave port; low power mode.
- Internal PLL generates up to 266 MHz clock for the SC1400 core and up to 133 MHz for the crossbar switch, DMA channels, M2 memory, and other peripherals.
- Clock synthesis module provides predivision of PLL input clock; independent clocking of the internal timers and DDR module; programmable operation in the SC1400 low power Stop mode; independent shutdown of different regions of the device.
- Enhanced 16-bit wide host interface (HDI16) provides a glueless connection to industry-standard microcomputers, microprocessors, and DSPs and can also operate with an 8-bit host data bus, making it fully compatible with the DSP56300 HI08 from the external host side.
- DDR memory controller that supports byte enables for up to a 32-bit data bus; glueless interface to 133 MHz 14-bit page mode DDR-RAM; 14-bit external address bus supporting up to 1 Gbyte; and 16-bit or 32-bit external data bus.
- Programmable memory interface with independent read buffers, programmable predictive read feature for each buffer, and a write buffer.
- System control unit performs software watchdog timer function; includes programmable bus time-out monitors on AHB-Lite slave buses; includes bus error detection and programmable time-out monitors on AHB-Lite master buses; and has address out-of-range detection on each crossbar switch buses.
- Event port collects and counts important signal events including DMA and interrupt requests and trigger events such as interrupts, breakpoints, DMA transfers, or wake-up events; units operate independently, in sequence, or triggered externally; can be used standalone or with the OCE10.
- Multi-channel DMA controller with 32 time-multiplexed unidirectional channels, priority-based time-multiplexing between channels using 32 internal priority levels, fixed- or round-robin-priority operation, major-minor loop structure, and DONE or DRACK protocol from requesting units.
- Two independent TDM modules with independent receive and transmit, programmable sharing of frame sync and clock, programmable word size (8 or 16-bit), hardware-base A-law/ $\mu$ -law conversion, up to 50 Mbps data rate per TDM, up to 128 channels, with glueless interface to E1/T1 frames and MVIP, SCAS, and H.110 buses.
- Ethernet controller with support for 10/100 Mbps MII/RMII designed to comply with IEEE Std. 802.3™, 802.3u™, 802.3x™, and 802.3ac™; with internal receive and transmit FIFOs and a FIFO controller; direct access to internal memories via its own DMA controller; full and half duplex operation; programmable maximum frame length; virtual local area network (VLAN) tag and priority support; retransmission of transmit FIFO following collision; CRC generation and verification for inbound and outbound packets; and address recognition including promiscuous, broadcast, individual address, hash/exact match, and multicast hash match.
- UART with full-duplex operation up to 5.0 Mbps.
- Up to 41 general-purpose input/output (GPIO) ports.
- I<sup>2</sup>C interface that allows booting from EEPROM devices up to 1 Mbyte.
- Two quad timer modules, each with sixteen configurable 16-bit timers.
- fieldBIST™ unit detects and provides visibility into unlikely field failures for systems with high availability to ensure structural integrity, that the device operates at the rated speed, is free from reliability defects, and reports diagnostics for partial or complete device inoperability.
- Standard JTAG interface allows easy integration to system firmware and internal on-chip emulation (OCE10) module.
- Optional booting external host via 8-bit or 16-bit access through the HDI16, I<sup>2</sup>C, or SPI using in the boot ROM to access serial SPI Flash/EEPROM devices; different clocking options during boot with the PLL on or off using a variety of input frequency ranges.



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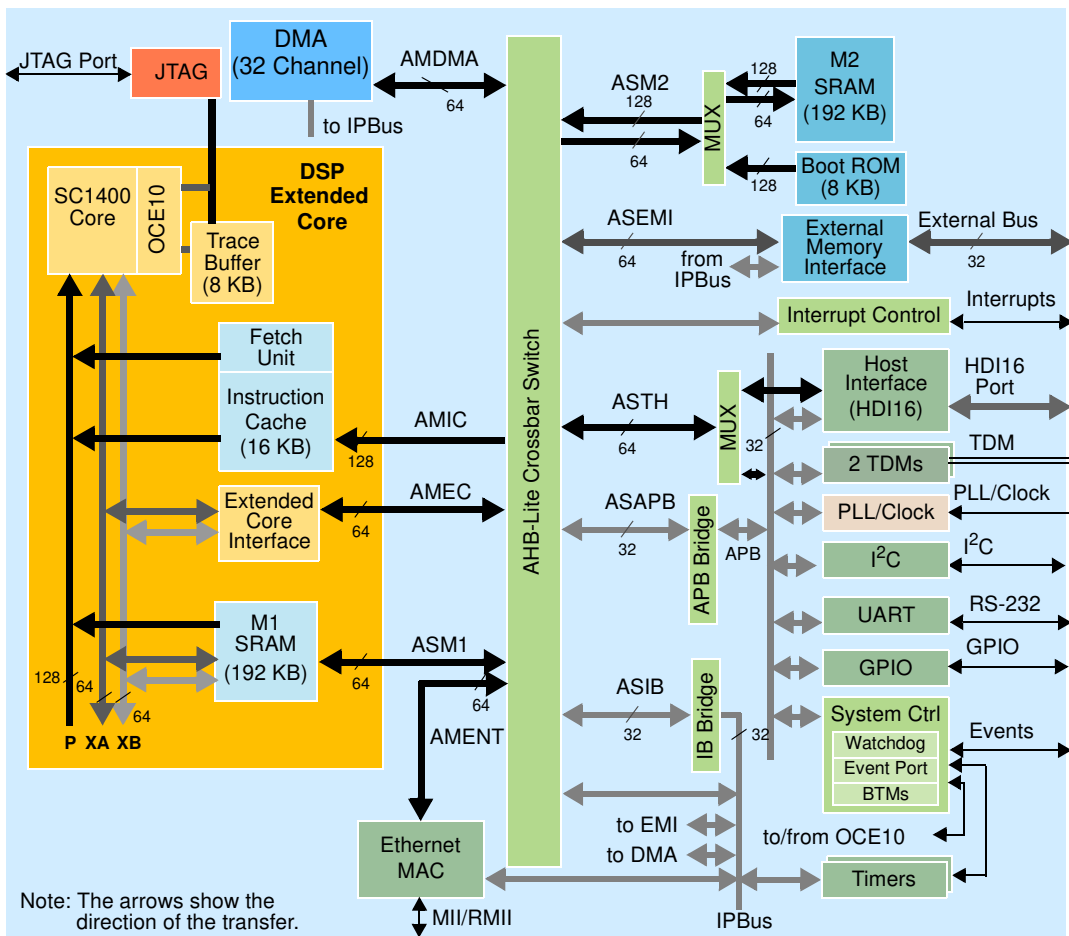


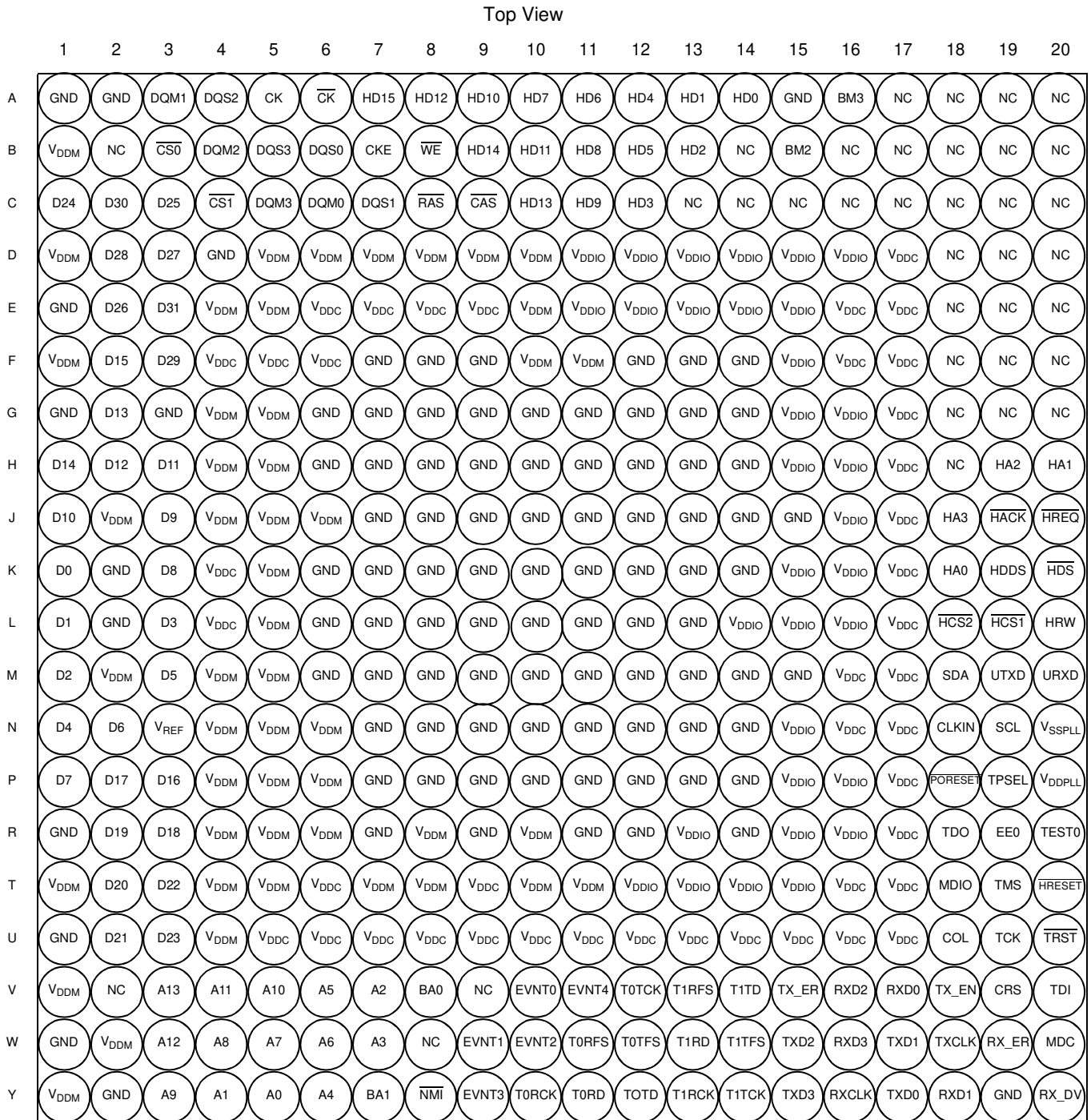
Figure 1. MSC7116 Block Diagram

# 1 Pin Assignments

This section includes diagrams of the MSC7116 package ball grid array layouts and pinout allocation tables.

## 1.1 MAP-BGA Ball Layout Diagrams

Top and bottom views of the MAP-BGA package are shown in **Figure 2** and **Figure 3** with their ball location index numbers.



**Figure 2. MSC7116 Molded Array Process-Ball Grid Array (MAP-BGA), Top View**

Bottom View

	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
A	NC	NC	NC	NC	BM3	GND	HD0	HD1	HD4	HD6	HD7	HD10	HD12	HD15	$\overline{CK}$	CK	DQS2	DQM1	GND	GND
B	NC	NC	NC	NC	NC	BM2	NC	HD2	HD5	HD8	HD11	HD14	$\overline{WE}$	CKE	DQS0	DQS3	DQM2	$\overline{CS0}$	NC	V <sub>DDM</sub>
C	NC	NC	NC	NC	NC	NC	NC	NC	HD3	HD9	HD13	$\overline{CAS}$	$\overline{RAS}$	DQS1	DQM0	DQM3	$\overline{CS1}$	D25	D30	D24
D	NC	NC	NC	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	GND	D27	D28	V <sub>DDM</sub>
E	NC	NC	NC	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDM</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	D31	D26	GND
F	NC	NC	NC	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDIO</sub>	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	GND	GND	GND	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	D29	D15	V <sub>DDM</sub>
G	NC	NC	NC	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	GND	D13	GND
H	HA1	HA2	NC	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	D11	D12	D14
J	$\overline{HREQ}$	$\overline{HACK}$	HA3	V <sub>DD</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	D9	V <sub>DDM</sub>	D10
K	$\overline{HDS}$	HDDS	HA0	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DD</sub>	D8	GND	D0
L	HRW	$\overline{HCS1}$	$\overline{HCS2}$	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DD</sub>	D3	GND	D1
M	URXD	UTXD	SDA	V <sub>DD</sub>	V <sub>DD</sub>	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	D5	V <sub>DDM</sub>	D2
N	V <sub>SSPLL</sub>	SCL	CLKIN	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>REF</sub>	D6	D4
P	V <sub>DDPLL</sub>	TPSEL	$\overline{PORESET}$	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	GND	GND	GND	GND	GND	GND	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	D16	D17	D7
R	TEST0	EE0	TDO	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GND	V <sub>DDIO</sub>	GND	GND	V <sub>DDM</sub>	GND	V <sub>DDM</sub>	GND	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	D18	D19	GND
T	$\overline{HRESET}$	TMS	MDIO	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDIO</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DD</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	V <sub>DD</sub>	V <sub>DDM</sub>	V <sub>DDM</sub>	D22	D20	V <sub>DDM</sub>
U	$\overline{TRST}$	TCK	COL	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>DDM</sub>	D23	D21	GND
V	TDI	CRS	TX_EN	RXD0	RXD2	TX_ER	T1TD	T1RFS	T0TCK	EVNT4	EVNT0	NC	BA0	A2	A5	A10	A11	A13	NC	V <sub>DDM</sub>
W	MDC	RX_ER	TXCLK	TXD1	RXD3	TXD2	T1TFS	T1RD	T0TFS	T0RFS	EVNT2	EVNT1	NC	A3	A6	A7	A8	A12	V <sub>DDM</sub>	GND
Y	RX_DV	GND	RXD1	TXD0	RXCLK	TXD3	T1TCK	T1RCK	T0TD	T0RD	T0RCK	EVNT3	$\overline{NMI}$	BA1	A4	A0	A1	A9	GND	V <sub>DDM</sub>

Figure 3. MSC7116 Molded Array Process-Ball Grid Array (MAP-BGA), Bottom View

## 1.2 Signal List By Ball Location

Table 1 lists the signals sorted by ball number and configuration.

Table 1. MSC7116 Signals by Ball Designator

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
A1	GND					
A2	GND					
A3	DQM1					
A4	DQS2					
A5	CK					
A6	$\overline{CK}$					
A7		GPIC7		GPOC7		HD15
A8		GPIC4		GPOC4		HD12
A9		GPIC2		GPOC2		HD10
A10		reserved				HD7
A11		reserved				HD6
A12		reserved				HD4
A13		reserved				HD1
A14		reserved				HD0
A15	GND					
A16	BM3	GPID8		GPOD8		reserved
A17	NC					
A18	NC					
A19	NC					
A20	NC					
B1	$V_{DDM}$					
B2	NC					
B3	$\overline{CS0}$					
B4	DQM2					
B5	DQS3					
B6	DQS0					
B7	CKE					
B8	$\overline{WE}$					
B9		GPIC6		GPOC6		HD14
B10		GPIC3		GPOC3		HD11
B11		GPIC0		GPOC0		HD8
B12		reserved				HD5
B13		reserved				HD2

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
B14	NC					
B15	BM2	GPID7		GPOD7	reserved	
B16	NC					
B17	NC					
B18	NC					
B19	NC					
B20	NC					
C1	D24					
C2	D30					
C3	D25					
C4	$\overline{\text{CS1}}$					
C5	DQM3					
C6	DQM0					
C7	DQS1					
C8	$\overline{\text{RAS}}$					
C9	$\overline{\text{CAS}}$					
C10	GPIC5			GPOC5	HD13	
C11	GPIC1			GPOC1	HD9	
C12	reserved				HD3	
C13	NC					
C14	NC					
C15	NC					
C16	NC					
C17	NC					
C18	NC					
C19	NC					
C20	NC					
D1	$V_{\text{DDM}}$					
D2	D28					
D3	D27					
D4	GND					
D5	$V_{\text{DDM}}$					
D6	$V_{\text{DDM}}$					
D7	$V_{\text{DDM}}$					
D8	$V_{\text{DDM}}$					
D9	$V_{\text{DDM}}$					



Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
D10						V <sub>DDM</sub>
D11						V <sub>DDIO</sub>
D12						V <sub>DDIO</sub>
D13						V <sub>DDIO</sub>
D14						V <sub>DDIO</sub>
D15						V <sub>DDIO</sub>
D16						V <sub>DDIO</sub>
D17						V <sub>DDC</sub>
D18						NC
D19						NC
D20						NC
E1						GND
E2						D26
E3						D31
E4						V <sub>DDM</sub>
E5						V <sub>DDM</sub>
E6						V <sub>DDC</sub>
E7						V <sub>DDC</sub>
E8						V <sub>DDC</sub>
E9						V <sub>DDC</sub>
E10						V <sub>DDM</sub>
E11						V <sub>DDIO</sub>
E12						V <sub>DDIO</sub>
E13						V <sub>DDIO</sub>
E14						V <sub>DDIO</sub>
E15						V <sub>DDIO</sub>
E16						V <sub>DDC</sub>
E17						V <sub>DDC</sub>
E18						NC
E19						NC
E20						NC
F1						V <sub>DDM</sub>
F2						D15
F3						D29
F4						V <sub>DDC</sub>
F5						V <sub>DDC</sub>

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
F6						V <sub>DDC</sub>
F7						GND
F8						GND
F9						GND
F10						V <sub>DDM</sub>
F11						V <sub>DDM</sub>
F12						GND
F13						GND
F14						GND
F15						V <sub>DDIO</sub>
F16						V <sub>DDC</sub>
F17						V <sub>DDC</sub>
F18						NC
F19						NC
F20						NC
G1						GND
G2						D13
G3						GND
G4						V <sub>DDM</sub>
G5						V <sub>DDM</sub>
G6						GND
G7						GND
G8						GND
G9						GND
G10						GND
G11						GND
G12						GND
G13						GND
G14						GND
G15						V <sub>DDIO</sub>
G16						V <sub>DDIO</sub>
G17						V <sub>DDC</sub>
G18						NC
G19						NC
G20						NC
H1						D14

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
H2					D12	
H3					D11	
H4					V <sub>DDM</sub>	
H5					V <sub>DDM</sub>	
H6					GND	
H7					GND	
H8					GND	
H9					GND	
H10					GND	
H11					GND	
H12					GND	
H13					GND	
H14					GND	
H15					V <sub>DDIO</sub>	
H16					V <sub>DDIO</sub>	
H17					V <sub>DDC</sub>	
H18					NC	
H19		reserved				HA2
H20		reserved				HA1
J1					D10	
J2					V <sub>DDM</sub>	
J3					D9	
J4					V <sub>DDM</sub>	
J5					V <sub>DDM</sub>	
J6					V <sub>DDM</sub>	
J7					GND	
J8					GND	
J9					GND	
J10					GND	
J11					GND	
J12					GND	
J13					GND	
J14					GND	
J15					GND	
J16					V <sub>DDIO</sub>	
J17					V <sub>DDC</sub>	

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
J18	GPIC11		GPOC11		HA3	
J19	reserved				$\overline{\text{HACK}}/\text{HACK}$ or $\overline{\text{HRRQ}}/\text{HRRQ}$	
J20	HDSP	reserved			$\overline{\text{HREQ}}/\text{HREQ}$ or $\overline{\text{HTRQ}}/\text{HTRQ}$	
K1	D0					
K2	GND					
K3	D8					
K4	$V_{\text{DDC}}$					
K5	$V_{\text{DDM}}$					
K6	GND					
K7	GND					
K8	GND					
K9	GND					
K10	GND					
K11	GND					
K12	GND					
K13	GND					
K14	GND					
K15	$V_{\text{DDIO}}$					
K16	$V_{\text{DDIO}}$					
K17	$V_{\text{DDC}}$					
K18	reserved				HA0	
K19	reserved				HDDS	
K20	reserved				$\overline{\text{HDS}}/\text{HDS}$ or $\overline{\text{HWR}}/\text{HWR}$	
L1	D1					
L2	GND					
L3	D3					
L4	$V_{\text{DDC}}$					
L5	$V_{\text{DDM}}$					
L6	GND					
L7	GND					
L8	GND					
L9	GND					
L10	GND					
L11	GND					
L12	GND					
L13	GND					



Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
L14	V <sub>DDIO</sub>					
L15	V <sub>DDIO</sub>					
L16	V <sub>DDIO</sub>					
L17	V <sub>DDC</sub>					
L18	GPIB11			GPOB11	$\overline{\text{HCS2}}/\text{HCS2}$	
L19	reserved			$\overline{\text{HCS1}}/\text{HCS1}$		
L20	reserved			HRW or $\overline{\text{HRD}}/\text{HRD}$		
M1	D2					
M2	V <sub>DDM</sub>					
M3	D5					
M4	V <sub>DDM</sub>					
M5	V <sub>DDM</sub>					
M6	GND					
M7	GND					
M8	GND					
M9	GND					
M10	GND					
M11	GND					
M12	GND					
M13	GND					
M14	GND					
M15	GND					
M16	V <sub>DDC</sub>					
M17	V <sub>DDC</sub>					
M18	GPIA14	$\overline{\text{IRQ15}}$	GPOA14	SDA		
M19	GPIA12	$\overline{\text{IRQ3}}$	GPOA12	UTXD		
M20	GPIA13	$\overline{\text{IRQ2}}$	GPOA13	URXD		
N1	D4					
N2	D6					
N3	V <sub>REF</sub>					
N4	V <sub>DDM</sub>					
N5	V <sub>DDM</sub>					
N6	V <sub>DDM</sub>					
N7	GND					
N8	GND					
N9	GND					

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
N10						GND
N11						GND
N12						GND
N13						GND
N14						GND
N15						V <sub>DDIO</sub>
N16						V <sub>DDC</sub>
N17						V <sub>DDC</sub>
N18						CLKIN
N19		GPIA15	$\overline{\text{IRQ14}}$	GPOA15		SCL
N20						V <sub>SSPLL</sub>
P1						D7
P2						D17
P3						D16
P4						V <sub>DDM</sub>
P5						V <sub>DDM</sub>
P6						V <sub>DDM</sub>
P7						GND
P8						GND
P9						GND
P10						GND
P11						GND
P12						GND
P13						GND
P14						GND
P15						V <sub>DDIO</sub>
P16						V <sub>DDIO</sub>
P17						V <sub>DDC</sub>
P18						$\overline{\text{PORESET}}$
P19						TPSEL
P20						V <sub>DDPLL</sub>
R1						GND
R2						D19
R3						D18
R4						V <sub>DDM</sub>
R5						V <sub>DDM</sub>

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
R6						V <sub>DDM</sub>
R7						GND
R8						V <sub>DDM</sub>
R9						GND
R10						V <sub>DDM</sub>
R11						GND
R12						GND
R13						V <sub>DDIO</sub>
R14						GND
R15						V <sub>DDIO</sub>
R16						V <sub>DDIO</sub>
R17						V <sub>DDC</sub>
R18						TDO
R19		reserved				EE0/DBREQ
R20						TEST0
T1						V <sub>DDM</sub>
T2						D20
T3						D22
T4						V <sub>DDM</sub>
T5						V <sub>DDM</sub>
T6						V <sub>DDC</sub>
T7						V <sub>DDM</sub>
T8						V <sub>DDM</sub>
T9						V <sub>DDC</sub>
T10						V <sub>DDM</sub>
T11						V <sub>DDM</sub>
T12						V <sub>DDIO</sub>
T13						V <sub>DDIO</sub>
T14						V <sub>DDIO</sub>
T15						V <sub>DDIO</sub>
T16						V <sub>DDC</sub>
T17						V <sub>DDC</sub>
T18		reserved				MDIO
T19						TMS
T20						$\overline{\text{HRESET}}$
U1						GND

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
U2					D21	
U3					D23	
U4					V <sub>DDM</sub>	
U5					V <sub>DDC</sub>	
U6					V <sub>DDC</sub>	
U7					V <sub>DDC</sub>	
U8					V <sub>DDC</sub>	
U9					V <sub>DDC</sub>	
U10					V <sub>DDC</sub>	
U11					V <sub>DDC</sub>	
U12					V <sub>DDC</sub>	
U13					V <sub>DDC</sub>	
U14					V <sub>DDC</sub>	
U15					V <sub>DDC</sub>	
U16					V <sub>DDC</sub>	
U17					V <sub>DDC</sub>	
U18		reserved				COL
U19					TCK	
U20					$\overline{\text{TRST}}$	
V1					V <sub>DDM</sub>	
V2					NC	
V3					A13	
V4					A11	
V5					A10	
V6					A5	
V7					A2	
V8					BA0	
V9					NC	
V10		reserved				EVNT0
V11	SWTE	GPIA16	$\overline{\text{IRQ12}}$	GPOA16		EVNT4
V12		GPIA8	$\overline{\text{IRQ6}}$	GPOA8		T0TCK
V13		GPIA4	$\overline{\text{IRQ1}}$	GPOA4		T1RFS
V14		GPIA0	$\overline{\text{IRQ11}}$	GPOA0		T1TD
V15		GPIA28	$\overline{\text{IRQ17}}$	GPOA28	TX_ER	reserved
V16		GPID6		GPOD6	RXD2	reserved
V17		GPIA22	$\overline{\text{IRQ22}}$	GPOA22		RXD0



Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
V18	GPIA24		$\overline{\text{IRQ24}}$	GPOA24	TX_EN	
V19	reserved				CRS	
V20	TDI					
W1	GND					
W2	$V_{\text{DDM}}$					
W3	A12					
W4	A8					
W5	A7					
W6	A6					
W7	A3					
W8	NC					
W9	GPIA17		$\overline{\text{IRQ13}}$	GPOA17	EVNT1	CLKO
W10	BM0	GPIC14		GPOC14	EVNT2	
W11	GPIA10		$\overline{\text{IRQ5}}$	GPOA10	T0RFS	
W12	GPIA7		$\overline{\text{IRQ7}}$	GPOA7	T0TFS	
W13	GPIA3		$\overline{\text{IRQ8}}$	GPOA3	T1RD	
W14	GPIA1		$\overline{\text{IRQ10}}$	GPOA1	T1TFS	
W15	GPID4			GPOD4	TXD2	reserved
W16	GPIA27		$\overline{\text{IRQ18}}$	GPOA27	RXD3	reserved
W17	GPIA19		$\overline{\text{IRQ19}}$	GPOA19	TXD1	
W18	GPIA23		$\overline{\text{IRQ23}}$	GPOA23	TXCLK or REFCLK	
W19	GPIA26		$\overline{\text{IRQ26}}$	GPOA26	RX_ER	
W20	H8BIT	reserved			MDC	
Y1	$V_{\text{DDM}}$					
Y2	GND					
Y3	A9					
Y4	A1					
Y5	A0					
Y6	A4					
Y7	BA1					
Y8	reserved		$\overline{\text{NMI}}$	reserved		
Y9	BM1	GPIC15		GPOC15	EVNT3	
Y10	GPIA11		$\overline{\text{IRQ4}}$	GPOA11	T0RCK	
Y11	GPIA9			GPOA9	T0RD	
Y12	GPIA6			GPOA6	T0TD	
Y13	GPIA5		$\overline{\text{IRQ0}}$	GPOA5	T1RCK	

Table 1. MSC7116 Signals by Ball Designator (continued)

Number	Signal Names					
	End of Reset	Software Controlled			Hardware Controlled	
		GPI Enabled (Default)	Interrupt Enabled	GPO Enabled	Primary	Alternate
Y14	GPIA2	$\overline{\text{IRQ9}}$	GPOA2	T1TCK		
Y15	GPIA29	$\overline{\text{IRQ16}}$	GPOA29	TXD3	reserved	
Y16	GPI D5		GPO D5	RXCLK	reserved	
Y17	GPIA20	$\overline{\text{IRQ20}}$	GPOA20	TXD0		
Y18	GPIA21	$\overline{\text{IRQ21}}$	GPOA21	RXD1		
Y19	GND					
Y20	GPIA25	$\overline{\text{IRQ25}}$	GPOA25	RX_DV or CRS_DV		

## 2 Electrical Characteristics

This document contains detailed information on power considerations, DC/AC electrical characteristics, and AC timing specifications. For additional information, see the *MSC711x Reference Manual*.

### 2.1 Maximum Ratings

#### CAUTION

**This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, normal precautions should be taken to avoid exceeding maximum voltage ratings. Reliability is enhanced if unused inputs are tied to an appropriate logic voltage level (for example, either GND or  $V_{DD}$ ).**

In calculating timing requirements, adding a maximum value of one specification to a minimum value of another specification does not yield a reasonable sum. A maximum specification is calculated using a worst case variation of process parameter values in one direction. The minimum specification is calculated using the worst case for the same parameters in the opposite direction. Therefore, a “maximum” value for a specification never occurs in the same device with a “minimum” value for another specification; adding a maximum to a minimum represents a condition that can never exist.

Table 2 describes the maximum electrical ratings for the MSC7116.

**Table 2. Absolute Maximum Ratings**

Rating	Symbol	Value	Unit
Core supply voltage	$V_{DDC}$	1.5	V
Memory supply voltage	$V_{DDM}$	4.0	V
PLL supply voltage	$V_{DDPLL}$	1.5	V
I/O supply voltage	$V_{DDIO}$	-0.2 to 4.0	V
Input voltage	$V_{IN}$	(GND - 0.2) to 4.0	V
Reference voltage	$V_{REF}$	4.0	V
Maximum operating temperature	$T_J$	105	°C
Minimum operating temperature	$T_A$	-40	°C
Storage temperature range	$T_{STG}$	-55 to +150	°C
<b>Notes:</b> <ol style="list-style-type: none"> <li>1. Functional operating conditions are given in <b>Table 3</b>.</li> <li>2. Absolute maximum ratings are stress ratings only, and functional operation at the maximum is not guaranteed. Stress beyond the listed limits may affect device reliability or cause permanent damage.</li> <li>3. <b>Section 3.1, Thermal Design Considerations</b> includes a formula for computing the chip junction temperature (<math>T_J</math>).</li> </ol>			

## 2.2 Recommended Operating Conditions

Table 3 lists recommended operating conditions. Proper device operation outside of these conditions is not guaranteed.

**Table 3. Recommended Operating Conditions**

Rating	Symbol	Value	Unit
Core supply voltage	$V_{DDC}$	1.14 to 1.26	V
Memory supply voltage	$V_{DDM}$	2.38 to 2.63	V
PLL supply voltage	$V_{DDPLL}$	1.14 to 1.26	V
I/O supply voltage	$V_{DDIO}$	3.14 to 3.47	V
Reference voltage	$V_{REF}$	1.19 to 1.31	V
Operating temperature range	$T_J$	maximum: 105	°C
	$T_A$	minimum: -40	°C

## 2.3 Thermal Characteristics

Table 4 describes thermal characteristics of the MSC7116 for the MAP-BGA package.

**Table 4. Thermal Characteristics for MAP-BGA Package**

Characteristic	Symbol	MAP-BGA 17 × 17 mm <sup>5</sup>		Unit
		Natural Convection	200 ft/min (1 m/s) airflow	
Junction-to-ambient <sup>1, 2</sup>	R <sub>θJA</sub>	39	31	°C/W
Junction-to-ambient, four-layer board <sup>1, 3</sup>	R <sub>θJA</sub>	23	20	°C/W
Junction-to-board <sup>4</sup>	R <sub>θJB</sub>	12		°C/W
Junction-to-case <sup>5</sup>	R <sub>θJC</sub>	7		°C/W
Junction-to-package-top <sup>6</sup>	Ψ <sub>JT</sub>	2		°C/W
<b>Notes:</b> <ol style="list-style-type: none"> <li>Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance).</li> <li>Per SEMI G38-87 and JEDEC JESD51-2 with the single layer board horizontal.</li> <li>Per JEDEC JESD51-6 with the board horizontal.</li> <li>Thermal resistance between the die and the printed circuit board per JEDEC JESD 51-8. Board temperature is measured on the top surface of the board near the package.</li> <li>Thermal resistance between the die and the case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1).</li> <li>Thermal characterization parameter indicating the temperature difference between package top and the junction temperature per JEDEC JESD51-2.</li> </ol>				

Section 3.1, *Thermal Design Considerations* explains these characteristics in detail.

## 2.4 DC Electrical Characteristics

This section describes the DC electrical characteristics for the MSC7116.

**Note:** The leakage current is measured for nominal voltage values must vary in the same direction (for example, both V<sub>DDIO</sub> and V<sub>DCC</sub> vary by +2 percent or both vary by -2 percent).

**Table 5. DC Electrical Characteristics**

Characteristic	Symbol	Min	Typical	Max	Unit
Core and PLL voltage	V <sub>DDC</sub> V <sub>DDPLL</sub>	1.14	1.2	1.26	V
DRAM interface I/O voltage <sup>1</sup>	V <sub>DDM</sub>	2.375	2.5	2.625	V
I/O voltage	V <sub>DDIO</sub>	3.135	3.3	3.465	V
DRAM interface I/O reference voltage <sup>2</sup>	V <sub>REF</sub>	0.49 × V <sub>DDM</sub>	1.25	0.51 × V <sub>DDM</sub>	V
DRAM interface I/O termination voltage <sup>3</sup>	V <sub>TT</sub>	V <sub>REF</sub> - 0.04	V <sub>REF</sub>	V <sub>REF</sub> + 0.04	V
Input high CLKIN voltage	V <sub>IHCLK</sub>	2.4	3.0	3.465	V
DRAM interface input high I/O voltage	V <sub>IHM</sub>	V <sub>REF</sub> + 0.28	V <sub>DDM</sub>	V <sub>DDM</sub> + 0.3	V
DRAM interface input low I/O voltage	V <sub>ILM</sub>	-0.3	GND	V <sub>REF</sub> - 0.18	V
Input leakage current, V <sub>IN</sub> = V <sub>DDIO</sub>	I <sub>IN</sub>	-1.0	0.09	1	μA
V <sub>REF</sub> input leakage current	I <sub>VREF</sub>	—	—	5	μA



**Table 5. DC Electrical Characteristics (continued)**

Characteristic	Symbol	Min	Typical	Max	Unit
Tri-state (high impedance off state) leakage current, $V_{IN} = V_{DDIO}$	$I_{OZ}$	-1.0	0.09	1	$\mu A$
Signal low input current, $V_{IL} = 0.4 V$	$I_L$	-1.0	0.09	1	$\mu A$
Signal high input current, $V_{IH} = 2.0 V$	$I_H$	-1.0	0.09	1	$\mu A$
Output high voltage, $I_{OH} = -2 mA$ , except open drain pins	$V_{OH}$	2.0	3.0	—	V
Output low voltage, $I_{OL} = 5 mA$	$V_{OL}$	—	0	0.4	V
Typical power at 266 MHz <sup>5</sup>	P	—	293.0	—	mW
<b>Notes:</b> <ol style="list-style-type: none"> <li>1. The value of <math>V_{DDM}</math> at the MSC7116 device must remain within 50 mV of <math>V_{DDM}</math> at the DRAM device at all times.</li> <li>2. <math>V_{REF}</math> must be equal to 50% of <math>V_{DDM}</math> and track <math>V_{DDM}</math> variations as measured at the receiver. Peak-to-peak noise must not exceed <math>\pm 2\%</math> of the DC value.</li> <li>3. <math>V_{TT}</math> is not applied directly to the MSC7116 device. It is the level measured at the far end signal termination. It should be equal to <math>V_{REF}</math>. This rail should track variations in the DC level of <math>V_{REF}</math>.</li> <li>4. Output leakage for the memory interface is measured with all outputs disabled, <math>0 V \leq V_{OUT} \leq V_{DDM}</math>.</li> <li>5. The core power values were measured using a standard EFR pattern at typical conditions (25°C, 300 MHz, 1.2 V core).</li> </ol>					

Table 6 lists the DDR DRAM capacitance.

**Table 6. DDR DRAM Capacitance**

Parameter/Condition	Symbol	Max	Unit
Input/output capacitance: DQ, DQS	$C_{IO}$	30	pF
Delta input/output capacitance: DQ, DQS	$C_{DIO}$	30	pF
<b>Note:</b> These values were measured under the following conditions: <ul style="list-style-type: none"> <li>• <math>V_{DDM} = 2.5 V \pm 0.125 V</math></li> <li>• <math>f = 1 MHz</math></li> <li>• <math>T_A = 25^\circ C</math></li> <li>• <math>V_{OUT} = V_{DDM}/2</math></li> <li>• <math>V_{OUT}</math> (peak to peak) = 0.2 V</li> </ul>			

## 2.5 AC Timings

This section presents timing diagrams and specifications for individual signals and parallel I/O outputs and inputs. All AC timings are based on a 30 pF load, except where noted otherwise, and a 50 Ω transmission line. For any additional pF, use the following equations to compute the delay:

- Standard interface:  $2.45 + (0.054 \times C_{load})$  ns
- DDR interface:  $1.6 + (0.002 \times C_{load})$  ns

### 2.5.1 Clock and Timing Signals

The following tables describe clock signal characteristics. **Table 6** shows the maximum frequency values for internal (core, reference, and peripherals) and external (CLKO) clocks. You must ensure that maximum frequency values are not exceeded (see **Section 2.5.2** for the allowable ranges when using the PLL).

**Table 6. Maximum Frequencies**

Characteristic	Maximum in MHz
Core clock frequency (CLOCK)	266
External output clock frequency (CLKO)	67
Memory clock frequency (CK, $\overline{CK}$ )	133
TDM clock frequency (TxRCK, TxTCK)	50

**Table 7. Clock Frequencies in MHz**

Characteristic	Symbol	Min	Max
CLKIN frequency	$F_{CLKIN}$	10	100
CLOCK frequency	$F_{CORE}$	—	266
CK, $\overline{CK}$ frequency	$F_{CK}$	—	133
TDMxRCK, TDMxTCK frequency	$F_{TDMCK}$	—	50
CLKO frequency	$F_{CKO}$	—	67
AHB/IPBus/APB clock frequency	$F_{BCK}$	—	133
<b>Note:</b> The rise and fall time of external clocks should be 5 ns maximum			

**Table 8. System Clock Parameters**

Characteristic	Min	Max	Unit
CLKIN frequency	10	100	MHz
CLKIN slope	—	5	ns
CLKIN frequency jitter (peak-to-peak)	—	1000	ps
CLKO frequency jitter (peak-to-peak)	—	133	ps

## 2.5.2 Configuring Clock Frequencies

This section describes important requirements for configuring clock frequencies in the MSC7116 device when using the PLL block. To configure the device clocking, you must program four fields in the Clock Control Register (CLKCTL):

- *PLLDVF field.* Specifies the PLL division factor ( $PLLDVF + 1$ ) to divide the input clock frequency  $F_{CLKIN}$ . The output of the divider block is the input to the multiplier block.
- *PLLMLTF field.* Specifies the PLL multiplication factor ( $PLLMLTF + 1$ ). The output from the multiplier block is the loop frequency  $F_{LOOP}$ .
- *RNG field.* Selects the available PLL frequency range for  $F_{VCO}$ , either  $F_{LOOP}$  when the RNG bit is set (1) or  $F_{LOOP}/2$  when the RNG bit is cleared (0).
- *CKSEL field.* Selects  $F_{CLKIN}$ ,  $F_{VCO}$ , or  $F_{VCO}/2$  as the source for the core clock.

There are restrictions on the frequency range permitted at the beginning of the multiplication portion of the PLL that affect the allowable values for the PLLDVF and PLLMLTF fields. The following sections define these restrictions and provide guidelines to configure the device clocking when using the PLL. Refer to the Clock and Power Management chapter in the *MSC711x Reference Manual* for details on the clock programming model.

### 2.5.2.1 PLL Multiplier Restrictions

There are two restrictions for correct usage of the PLL block:

- The input frequency to the PLL multiplier block (that is, the output of the divider) must be in the range 10–25 MHz.
- The output frequency of the PLL multiplier must be in the range 266–532 MHz.

When programming the PLL for a desired output frequency using the PLLDVF, PLLMLTF, and RNG fields, you must meet these constraints.

### 2.5.2.2 Input Division Factors and Corresponding CLKIN Frequency Range

The value of the PLLDVF field determines the allowable CLKIN frequency range, as shown in **Table 9**.

**Table 9. CLKIN Frequency Ranges by Divide Factor Value**

PLLDVF Field Value	Input Divide Factor	CLKIN Frequency Range	Comments
0x00	1	10 to 25 MHz	Input Division by 1
0x01	2	20 to 50 MHz	Input Division by 2
0x02	3	30 to 75 MHz	Input Division by 3
0x03	4	40 to 100 MHz	Input Division by 4
0x04	5	50 to 100 MHz	Input Division by 5
0x05	6	60 to 100 MHz	Input Division by 6
0x06	7	70 to 100 MHz	Input Division by 7
0x07	8	80 to 100 MHz	Input Division by 8
0x08	9	90 to 100 MHz	Input Division by 9
0x09	10	100 MHz	Input Division by 10

**Note:** The maximum CLKIN frequency is 100 MHz. Therefore, the PLLDVF value must be in the range from 1–10.

### 2.5.2.3 Multiplication Factor Range

The multiplier block output frequency ranges depend on the divided input clock frequency as shown in **Table 10**.

**Table 10. PLLMLTF Ranges**

Multiplier Block (Loop) Output Range	Minimum PLLMLTF Value	Maximum PLLMLTF Value
$266 \leq [\text{Divided Input Clock} \times (\text{PLLMLTF} + 1)] \leq 532 \text{ MHz}$	266/Divided Input Clock	532/Divided Input Clock
<b>Note:</b> This table results from the allowed range for $F_{\text{Loop}}$ . The minimum and maximum multiplication factors are dependent on the frequency of the Divided Input Clock.		

### 2.5.2.4 Allowed Core Clock Frequency Range

The frequency delivered to the core, extended core, and peripherals depends on the value of the CLKCTRL[RNG] bit as shown in **Table 11**.

**Table 11.  $F_{\text{VCO}}$  Frequency Ranges**

CLKCTRL[RNG] Value	Allowed Range of $F_{\text{VCO}}$
1	$266 \leq F_{\text{VCO}} \leq 532 \text{ MHz}$
0	$133 \leq F_{\text{VCO}} \leq 266 \text{ MHz}$
<b>Note:</b> This table results from the allowed range for $F_{\text{VCO}}$ , which is $F_{\text{Loop}}$ modified by CLKCTRL[RNG].	

This bit along with the CKSEL determines the frequency range of the core clock.

**Table 12. Resulting Ranges Permitted for the Core Clock**

CLKCTRL[CKSEL]	CLKCTRL[RNG]	Resulting Division Factor	Allowed Range of Core Clock	Comments
11	1	1	Reserved	Reserved
11	0	2	$133 \leq \text{core clock} \leq 266 \text{ MHz}$	Limited by range of PLL
01	1	2	$133 \leq \text{core clock} \leq 266 \text{ MHz}$	Limited by range of PLL
01	0	4	$66.5 \leq \text{core clock} \leq 133 \text{ MHz}$	Limited by range of PLL
<b>Note:</b> This table results from the allowed range for $F_{\text{OUT}}$ , which depends on clock selected via CLKCTRL[CKSEL].				

### 2.5.2.5 Core Clock Frequency Range When Using DDR Memory

The core clock can also be limited by the frequency range of the DDR devices in the system. **Table 13** summarizes this restriction.

**Table 13. Core Clock Ranges When Using DDR**

DDR Type	Allowed Frequency Range for DDR CK	Corresponding Range for the Core Clock	Comments
DDR 200 (PC-1600)	83–100 MHz	$166 \leq \text{core clock} \leq 200 \text{ MHz}$	Core limited to $2 \times$ maximum DDR frequency
DDR 266 (PC-2100) DDR 333 (PC-2600)	83–133 MHz	$166 \leq \text{core clock} \leq 266 \text{ MHz}$	Core limited to $2 \times$ maximum DDR frequency

## 2.5.3 Reset Timing

The MSC7116 device has several inputs to the reset logic. All MSC7116 reset sources are fed into the reset controller, which takes different actions depending on the source of the reset. The reset status register indicates the most recent sources to cause a reset. **Table 14** describes the reset sources.

**Table 14. Reset Sources**

Name	Direction	Description
Power-on reset (PORESET)	Input	Initiates the power-on reset flow that resets the MSC7116 and configures various attributes of the MSC7116. On PORESET, the entire MSC7116 device is reset. SPLL and DLL states are reset, HRESET is driven, the SC1400 extended core is reset, and system configuration is sampled. The system is configured only when PORESET is asserted.
External Hard reset (HRESET)	Input/ Output	Initiates the hard reset flow that configures various attributes of the MSC7116. While HRESET is asserted, HRESET is an open-drain output. Upon hard reset, HRESET is driven and the SC1400 extended core is reset.
Software watchdog reset	Internal	When the MSC7116 watchdog count reaches zero, a software watchdog reset is signalled. The enabled software watchdog event then generates an internal hard reset sequence.
Bus monitor reset	Internal	When the MSC7116 bus monitor count reaches zero, a bus monitor hard reset is asserted. The enabled bus monitor event then generates an internal hard reset sequence.
JTAG EXTEST, CLAMP, or HIGHZ command	Internal	When a Test Access Port (TAP) executes an EXTEST, CLAMP, or HIGHZ command, the TAP logic asserts an internal reset signal that generates an internal soft reset sequence.

**Table 15** summarizes the reset actions that occur as a result of the different reset sources.

**Table 15. Reset Actions for Each Reset Source**

Reset Action/Reset Source	Power-On Reset (PORESET)	Hard Reset (HRESET)	Soft Reset (SRESET)
	External only	External or Internal (Software Watchdog or Bus Monitor)	JTAG Command: EXTEST, CLAMP, or HIGHZ
Configuration pins sampled (refer to <b>Section 2.5.3.1</b> for details).	Yes	No	No
PLL and clock synthesis states Reset	Yes	No	No
HRESET Driven	Yes	Yes	No
Software watchdog and bus time-out monitor registers	Yes	Yes	Yes
Clock synthesis modules (STOPCTRL, HLTREQ, and HLTACK) reset	Yes	Yes	Yes
Extended core reset	Yes	Yes	Yes
Peripheral modules reset	Yes	Yes	Yes

### 2.5.3.1 Power-On Reset (PORESET) Pin

Asserting PORESET initiates the power-on reset flow. PORESET must be asserted externally for at least 16 CLKIN cycles after external power to the MSC7116 reaches at least  $2/3 V_{DD}$ .

### 2.5.3.2 Reset Configuration

The MSC7116 has two mechanisms for writing the reset configuration:

- From a host through the host interface (HDI16)
- From memory through the I<sup>2</sup>C interface

Five signal levels (see **Chapter 1** for signal description details) are sampled on  $\overline{\text{PORESET}}$  deassertion to define the boot and operating conditions:

- BM[0–1]
- SWTE
- H8BIT
- HDSP

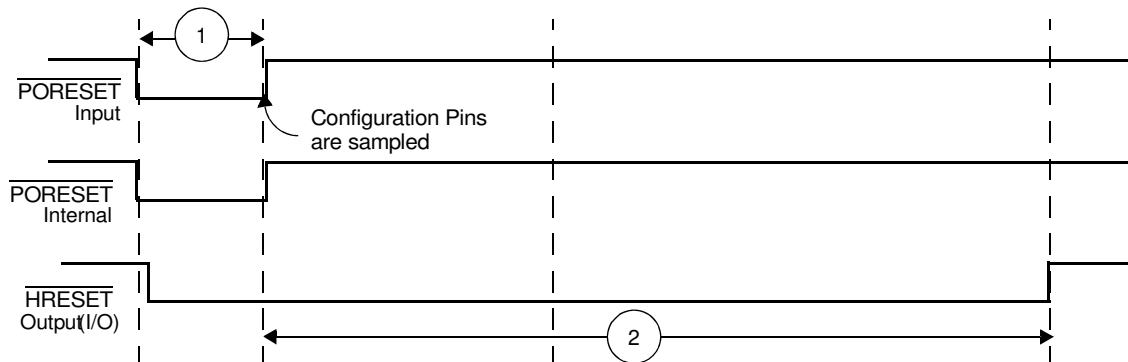
### 2.5.3.3 Reset Timing Tables

**Table 16** and **Figure 4** describe the reset timing for a reset configuration write.

**Table 16. Timing for a Reset Configuration Write**

No.	Characteristics	Expression	Unit
1	Required external $\overline{\text{PORESET}}$ duration minimum	$16/F_{\text{CLKIN}}$	clocks
2	Delay from $\overline{\text{PORESET}}$ deassertion to $\overline{\text{HRESET}}$ deassertion	$521/F_{\text{CLKIN}}$	clocks

**Note:** Timings are not tested, but are guaranteed by design.



**Figure 4. Timing Diagram for a Reset Configuration Write**