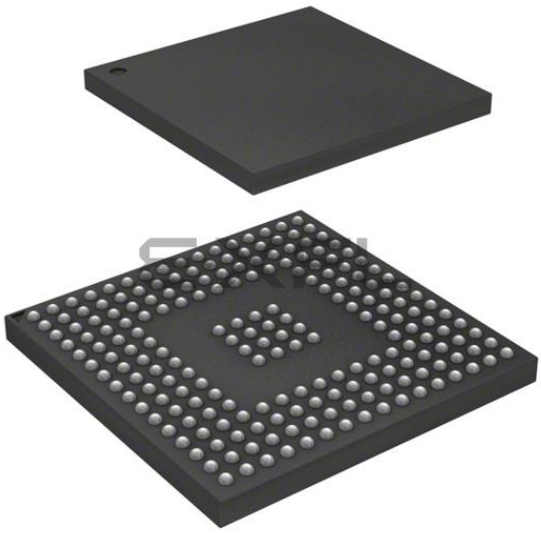

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	e200z650
Core Size	32-Bit Single-Core
Speed	116MHz
Connectivity	CANbus, I²C, LINbus, SCI, SPI
Peripherals	DMA, POR, PWM, WDT
Number of I/O	155
Program Memory Size	2MB (2M x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 5.5V
Data Converters	A/D 64x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	208-BGA
Supplier Device Package	208-BGA (17x17)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/spc5668ek0mmgr

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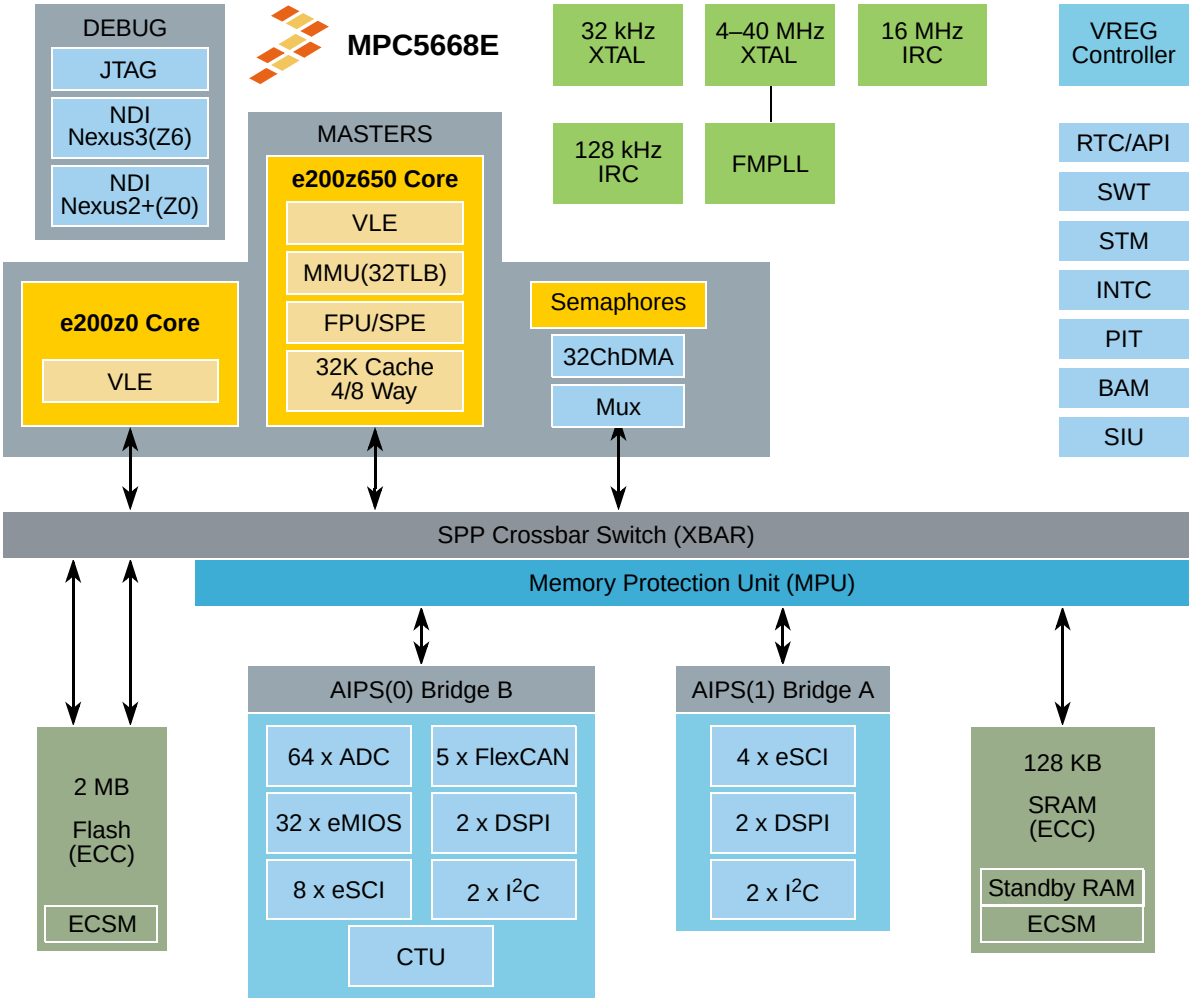
Table 1. MPC5668G/MPC5668E Comparison

Feature	MPC5668G		MPC5668E	
Package	**208 MAPBGA**	**256 MAPBGA**	**208 MAPBGA**	**256 MAPBGA**
RAM with ECC	592 KB		128 KB	
MPU	No		16 entry	
DMA	16-channel		32-channel	
Ethernet (FEC)	Yes		No	
MediaLB (MLB-DIM)	Yes		No	
FlexRay	Yes (128 Message Buffers)		No	
ADC (10-bit)	36 internal channels Supports 32 external channels		64 internal channels Supports 32 external channels	
Total Timer I/O (eMIOS200)	24 channels, 16-bit		32 channels, 16-bit	
Cross Trigger Unit (CTU)	No		Yes	
SCI (eSCI)	6		12	
SPI (DSPI)	4		4	
CAN (FlexCAN)	6		5	
I^2C	4		4	
Nexus3 Debug (e200Z6) Nexus2+ Debug (e200Z0)	—	Supported on 256BGA emulation package	—	Supported on 256BGA emulation package

Figure 2 shows a top level block diagram for the MPC5668E device.



LEGEND

ADC	– Analog to Digital Converter	**I²C**	– Inter IC Controller
BAM	– Boot Assist Module	**INTC**	– Interrupt Controller
CTU	– Cross Triggering Unit	**JTAG**	– Joint Test Action Group interface
DSPI	– Serial Peripherals Interface controller	**MPU**	– Memory Protection Unit
ECC	– Error Correction Code	**NDI**	– Nexus Debug Interface
ECSM	– Error Correction Status Module	**PIT**	– Periodic Interrupt Timer
eDMA	– Enhanced Direct Memory Access controller	**RTC**	– Real Time Clock
eMIOS200	– Timed Input Output	**SIU**	– System Integration
eSCI	– Serial Communications Interface	**STM**	– System Timer Module
FlexCAN	– Controller Area Network controller	**SWT**	– Software Watchdog Timer
FMPLL	– Frequency Modulated Phase Locked Loop	**VREG**	– Voltage Regulator

Figure 2. MPC5668E Block Diagram

Table 2. MPC5668x Signal Properties (continued)

Pin Name[1]	Supported Functions[2]	GPIO (PCR) Num[3]	PA[4]	Description	I/O Type	Volt-age	Pad Type[5]	Status		Package Pin Locations	
								During Reset[6]	After Reset[7]	208 BGA	256 BGA
PB10	PB[10] AN[26] PCS_B[4]	26	00 01 10 11	Port B GPIO ADC Analog Input DSPI_B Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	A9	A9
PB11	PB[11] AN[27] PCS_B[5]	27	00 01 10 11	Port B GPIO ADC Analog Input DSPI_B Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	B9	B9
PB12	PB[12] AN[28] PCS_C[1]	28	00 01 10 11	Port B GPIO ADC Analog Input DSPI_C Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	C10	C10
PB13	PB[13] AN[29] PCS_C[2]	29	00 01 10 11	Port B GPIO ADC Analog Input DSPI_C Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	A8	A8
PB14	PB[14] AN[30] PCS_D[3]	30	00 01 10 11	Port B GPIO ADC Analog Input DSPI_D Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	B8	B8
PB15	PB[15] AN[31] PCS_D[4]	31	00 01 10 11	Port B GPIO ADC Analog Input DSPI_D Peripheral Chip Select —	I/O I O —	V_{DDE1}	SHA	—	—	C9	C9
Port C (16)											
PC0	PC[0] AN[32]	32	00 01 10 11	Port C GPIO ADC Analog Input — —	I/O I — —	V_{DDE1}	SHA	—	—	D9	D9
PC1	PC[1] AN[33]	33	00 01 10 11	Port C GPIO ADC Analog Input — —	I/O I — —	V_{DDE1}	SHA	—	—	C8	C8
PC2	PC[2] AN[34] EVTI	34	00 01 10 11	Port C GPIO ADC Analog Input Nexus Event In —	I/O I I —	V_{DDE1}	SHA	—	—	A7	A7
PC3	PC[3] AN[35] EVTO	35	00 01 10 11	Port C GPIO ADC Analog Input Nexus Event Out —	I/O I O —	V_{DDE1}	SHA	—	—	B7	B7

Table 2. MPC5668x Signal Properties (continued)

Pin Name[1]	Supported Functions[2]	GPIO (PCR) Num[3]	PA[4]	Description	I/O Type	Volt-age	Pad Type[5]	Status		Package Pin Locations	
								During Reset[6]	After Reset[7]	208 BGA	256 BGA
PC15	PC[15] AN[47] MA[2] —	47	00 01 10 11	Port C GPIO ADC Analog Input ADC Ext. Mux Address Select —	I/O I O —	V_{DDE1}	SHA	—	—	D5	D5
Port D (16)											
PD0	PD[0] CNTX_A	48	00 01 10 11	Port D GPIO FlexCAN_A Transmit — —	I/O O — —	V_{DDE2}	SH	—	—	A2	A2
PD1	PD[1] CNRX_A	49	00 01 10 11	Port D GPIO FlexCAN_A Receive — —	I/O I — —	V_{DDE2}	SH	—	—	B2	B2
PD2	PD[2] CNTX_B	50	00 01 10 11	Port D GPIO FlexCAN_B Transmit — —	I/O O — —	V_{DDE2}	SH	—	—	B1	B1
PD3	PD[3] CNRX_B	51	00 01 10 11	Port D GPIO FlexCAN_B Receive — —	I/O I — —	V_{DDE2}	SH	—	—	C1	C1
PD4	PD[4] CNTX_C	52	00 01 10 11	Port D GPIO FlexCAN_C Transmit — —	I/O O — —	V_{DDE2}	SH	—	—	C2	C2
PD5	PD[5] CNRX_C	53	00 01 10 11	Port D GPIO FlexCAN_C Receive — —	I/O I — —	V_{DDE2}	SH	—	—	D1	D1
PD6	PD[6] CNTX_D TXD_K SCL_B	54	00 01 10 11	Port D GPIO FlexCAN_D Transmit SCI_K Transmit I^2C_B Serial Clock	I/O O O I/O	V_{DDE2}	SH	—	—	D2	D2
PD7	PD[7] CNRX_D RXD_K SDA_B	55	00 01 10 11	Port D GPIO FlexCAN_D Receive SCI_K Receive I^2C_B Serial Data	I/O I I I/O	V_{DDE2}	SH	—	—	E1	E1
PD8	PD[8] CNTX_E TXD_L SCL_C	56	00 01 10 11	Port D GPIO FlexCAN_E Transmit SCI_L Transmit I^2C_C Serial Clock	I/O O O I/O	V_{DDE2}	SH	—	—	E2	E2

Table 2. MPC5668x Signal Properties (continued)

Pin Name[1]	Supported Functions[2]	GPIO (PCR) Num[3]	PA[4]	Description	I/O Type	Volt-age	Pad Type[5]	Status		Package Pin Locations	
								During Reset[6]	After Reset[7]	208 BGA	256 BGA
PF8	PF[8] SCK_C	88	00 01 10 11	Port F GPIO DSPI_C Serial Clock — —	I/O I/O — —	V_{DDE2}	MH	—	—	P1	P1
PF9	PF[9] SOUT_C	89	00 01 10 11	Port F GPIO DSPI_C Serial Data Out — —	I/O O — —	V_{DDE2}	MH	—	—	T2	T2
PF10	PF[10] SIN_C	90	00 01 10 11	Port F GPIO DSPI_C Serial Data In — —	I/O I — —	V_{DDE2}	SH	—	—	R1	R1
PF11	PF[11] PCS_C[0] PCS_D[5] PCS_A[4]	91	00 01 10 11	Port F GPIO DSPI_C Peripheral Chip Select DSPI_D Peripheral Chip Select DSPI_A Peripheral Chip Select	I/O I/O O O	V_{DDE2}	SH	—	—	R3	R3
PF12	PF[12] SCK_D	92	00 01 10 11	Port F GPIO DSPI_D Serial Clock — —	I/O I/O — —	V_{DDE3}	MH	—	—	N14	N14
PF13	PF[13] SOUT_D	93	00 01 10 11	Port F GPIO DSPI_D Serial Data Out — —	I/O O — —	V_{DDE3}	MH	—	—	M14	M14
PF14	PF[14] SIN_D	94	00 01 10 11	Port F GPIO DSPI_D Serial Data In — —	I/O I — —	V_{DDE3}	SH	—	—	P14	P14
PF15	PF[15] PCS_D[0] PCS_A[5] PCS_B[4]	95	00 01 10 11	Port F GPIO DSPI_D Peripheral Chip Select DSPI_A Peripheral Chip Select DSPI_B Peripheral Chip Select	I/O I/O O O	V_{DDE3}	SH	—	—	P13	P13
Port G (16)											
PG0	PG[0] PCS_A[4] PCS_B[3] AN[48]	96	00 01 10 11	Port G GPIO DSPI_A Peripheral Chip Select DSPI_B Peripheral Chip Select ADC Analog Input	I/O O O I	V_{DDE2}	SHA	—	—	B3	B3
PG1	PG[1] PCS_A[5] PCS_B[4] AN[49]	97	00 01 10 11	Port G GPIO DSPI_A Peripheral Chip Select DSPI_B Peripheral Chip Select ADC Analog Input	I/O O O I	V_{DDE2}	SHA	—	—	A3	A3

3.3.1 Power and Ground Supply Summary

Table 3. MPC5668x Power/Ground

Pin Name	Function Description	Voltage[1]	Package Pin Locations	
			208	256
V_{DD}	Internal Logic Power	1.2 V	D4, D10, H4, G13, K13, N5	D4, D10, H4, G13, K13, N5
V_{DDE1}	External I/O Power	3.3–5.0 V	D6	D6
V_{DDE2}			L4	L4
V_{DDE3}			J13	J13
V_{DDE4}			N10	N10
V_{DDA}	Analog Power	3.3–5.0 V	B15	B15
V_{DD33}	3.3 V I/O Power	3.3 V	L13	L13
V_{DDEMLB}	Media Local Bus Power	2.5 or 3.3 V	K4	K4
V_{DDENEX}[2]	Nexus Power	3.3 V	—	E6, K11, L7
V_{RCSEL}	Voltage Regulator Select	V_{SSA} / V_{DDA}	H13	H13
V_{RC}	Voltage Regulator Control Voltage	3.3–5.0 V	B10	B10
V_{RCCTL}	Voltage Regulator Control Output	—[3]	B11	B11
V_{DDSYN}	Clock Synthesizer Power	3.3 V	A12	A12
V_{RH}	Analog High Voltage Reference	3.3–5.0 V	B16	B16
V_{RL}	Analog Low Voltage Reference	0 V	C16	C16
V_{SS}	Ground	0 V	A1, A16, D7, G4, G[7:10], H[7:10], J[7:10], K[7:10], N13, T1, T16	A1, A16, D7, E[7:12], F[7:12], G4, G[6:12], H[7:12], J[7:12], K[6:10], K12, L[8:10], L12, N13, T1, T16
V_{SSA}	Analog Ground	0 V	C15	C15
V_{SSSYN}	Clock Synthesizer Ground	0 V	A15	A15

1 Nominal voltages.

2 Dedicated Nexus power pin on 256-pin package only. On the 208-pin package, VDDENEX is tied to VSS internal to the package substrate and is not available externally.

3 Base current to external NPN power transistor. Voltage may vary.

4 Electrical Characteristics

This section contains detailed information on power considerations, DC/AC electrical characteristics, and AC timing specifications for the MPC5668x.

4.1 Maximum Ratings

Table 4. Absolute Maximum Ratings[1]

Spec	Characteristic	Symbol	Min	Max	Unit
1	1.2 V Core Supply Voltage[2]	V_{DD}	–0.3	1.32[3]	V
2	3.3 V Clock Synthesizer Voltage[2, 4]	V_{DDSYN}	–0.3	3.6	V
3	3.3 V I/O Buffer Voltage [2, 4]	V_{DD33}	–0.3	3.6	V
4	3.3–5.0 V Voltage Regulator Control Voltage [2, 5, 6]	V_{RC}	–0.3	5.5	V
5	3.3–5.0 V Analog Supply Voltage (reference to V_{SSA}) [2, 5]	V_{DDA}	–0.3	5.5	V
6	3.3–5.0 V External I/O Supply Voltage [2, 5, 7]	V_{DDE1}[8] V_{DDE2}[8] V_{DDE3}[8] V_{DDE4}[8]	–0.3 –0.3 –0.3 –0.3	5.5 5.5 5.5 5.5	V
7	2.5–3.3 V External I/O Supply Voltage (MLB) [2, 4]	V_{DDEMLB}[8]	–0.3	3.6	V
8	3.3 V External I/O Supply Voltage (Nexus) [2, 4]	V_{DDENEX}[8]	–0.3	3.6	V
9	DC Input Voltage[9] V_{DDE1}, V_{DDE2}, V_{DDE3}, V_{DDE4} V_{DDEMLB}, V_{DDENEX}	V_{IN}	 –1.0[10] –1.0[9]	 V_{DDEx} + 0.3 V[11] V_{DDEx} + 0.3 V[10]	V
10	Analog Reference High Voltage	V_{RH}	–0.3	Minimum of 5.5 or V_{DDA} + 0.3	V
11	Analog Reference Low Voltage	V_{RL}	–0.3	5.5	V
12	V_{SS} to V_{SSA} Differential Voltage	$V_{SS} – V_{SSA}$	–100	100	mV
13	V_{SS} to V_{SSSYN} Differential Voltage	$V_{SS} – V_{SSSYN}$	–100	100	mV
14	Maximum DC Digital Input Current[12] (per pin, applies to all digital F, MH, SH, and IH pins)	I_{MAXD}	–2	2	mA
15	Maximum DC Analog Input Current[13] (per pin, applies to all analog AE and A pins)	I_{MAXA}	–3	3	mA
16	Storage Temperature Range	T_{STG}	–55.0	150.0	°C
17	Maximum Solder Temperature[14]	T_{SDR}	—	235.0	°C
18	Moisture Sensitivity Level[15]	MSL	—	3	

1 Functional operating conditions are given in the DC electrical specifications. Absolute maximum ratings are stress ratings only, and functional operation at the maxima is not guaranteed. Stress beyond the listed maxima may affect device reliability or cause permanent damage to the device.

2 Voltage overshoots during a high-to-low or low-to-high transition must not exceed 10 seconds per instance.

3 2.0 V for 10 hours cumulative time, 1.2 V +10% for time remaining.

4 5.3 V for 10 hours cumulative time, 3.3 V +10% for time remaining.

5 6.4 V for 10 hours cumulative time, 5.0 V +10% for time remaining.

6 VRC cannot be 100mV higher than VDDA. VDDSYN and VDD33 cannot be 100mV higher than VRC.

7 All functional non-supply I/O pins are clamped to V_{SS} and V_{DDEx}.

8 V_{DDEx} are separate power segments and may be powered independently with no differential voltage constraints between the power segments.

9 AC signal over and undershoot of the input voltages of up to ±2.0 V is permitted for a cumulative duration of 60 hours over the complete lifetime of the device (injection current does not need to be limited for this duration).

10 Internal structures will hold the input voltage above –1.0 V if the injection current limit of 2 mA is met.

11 Internal structures hold the input voltage below this maximum voltage on all pads powered by V_{DDE} supplies, if the maximum injection current specification is met (25 mA for all pins) and V_{DDE} is within Operating Voltage specifications.

12 Total injection current for all pins (including both digital and analog) must not exceed 25 mA.

13 Total injection current for all analog input pins must not exceed 15 mA.

14 Solder profile per CDF-AEC-Q100.

15 Moisture sensitivity per JEDEC test method A112.

4.2 Thermal Characteristics

Table 5. Thermal Characteristics

Spec	Characteristic	Symbol	Unit	Value	
				208 MAPBGA	256 MAPBGA
1	Junction to Ambient[1, 2] Natural Convection (Single layer board)	$R_{\theta JA}$	°C/W	39	39
2	Junction to Ambient[1, 3] Natural Convection (Four layer board 2s2p)	$R_{\theta JA}$	°C/W	24	24
3	Junction to Ambient[1, 3] (@200 ft./min., Single layer board)	$R_{\theta JMA}$	°C/W	31	31
4	Junction to Ambient[1, 3] (@200 ft./min., Four layer board 2s2p)	$R_{\theta JMA}$	°C/W	20	20
5	Junction to Board[4]	$R_{\theta JB}$	°C/W	13	13
6	Junction to Case[5]	$R_{\theta JC}$	°C/W	6	6
7	Junction to Package Top[6] Natural Convection	Ψ_{JT}	°C/W	2	2

1 Junction temperature is a function of 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.

2 Per SEMI G38-87 and JEDEC JESD51-2 with the single layer board horizontal.

3 Per JEDEC JESD51-6 with the board horizontal.

4 Thermal resistance between the die and the printed circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.

5 Indicates the average thermal resistance between the die and the case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1) with the cold plate temperature used for the case temperature.

6 Thermal characterization parameter indicating the temperature difference between package top and the junction temperature per JEDEC JESD51-2.

4.2.1 General Notes for Specifications at Maximum Junction Temperature

An estimation of the chip junction temperature, T_J, can be obtained from the equation:

$$T_J = T_A + (R_{\theta JA} \times P_D) \quad \textit{Eqn. 1}$$

where:

T_A = ambient temperature for the package (^oC)

$R_{\theta JA}$ = junction to ambient thermal resistance ($^oC/W$)

P_D = power dissipation in the package (W)

The supplied thermal resistances are provided based on JEDEC JESD51 series of standards to provide consistent values for estimations and comparisons. The difference between the values determined on the single-layer (1s) board and on the four-layer board with two signal layers and a power and a ground plane (2s2p) clearly demonstrate that the effective thermal resistance of the component is not a constant. It depends on the construction of the application board (number of planes), the effective size of the board which cools the component, how well the component is thermally and electrically connected to the planes, and the power being dissipated by adjacent components.

Connect all the ground and power balls to the respective planes with one via per ball. Using fewer vias to connect the package to the planes reduces the thermal performance. Thinner planes also reduce the thermal performance. When the clearance between through vias leave the planes virtually disconnected, the thermal performance is also greatly reduced.

As a general rule, the value obtained on a single layer board is appropriate for the tightly packed printed circuit board. The value obtained on the board with the internal planes is usually appropriate if the application board has one oz. (35 micron nominal thickness) internal planes, the components are well separated, and the overall power dissipation on the board is less than 0.02 W/cm^2.

The thermal performance of any component depends strongly on the power dissipation of surrounding components. In addition, the ambient temperature varies widely within the application. For many natural convection and especially closed box applications, the board temperature at the perimeter (edge) of the package is approximately the same as the local air temperature near the device. Specifying the local ambient conditions explicitly as the board temperature provides a more precise description of the local ambient conditions that determine the temperature of the device.

At a known board temperature, the junction temperature is estimated using the following equation:

$$T_J = T_B + (R_{\theta JB} \times P_D) \quad \textit{Eqn. 2}$$

where:

T_J = junction temperature (^oC)

T_B = board temperature at the package perimeter ($^oC/W$)

$R_{\theta JB}$ = junction to board thermal resistance ($^oC/W$) per JESD51-8

P_D = power dissipation in the package (W)

When the heat loss from the package case to the air can be ignored, acceptable predictions of junction temperature can be made. The application board should be similar to the thermal test condition, with the component soldered to a board with internal planes.

Historically, the thermal resistance has frequently been expressed as the sum of a junction to case thermal resistance and a case to ambient thermal resistance:

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CA} \quad \textit{Eqn. 3}$$

where:

$R_{\theta JA}$ = junction to ambient thermal resistance ($^oC/W$)

$R_{\theta JC}$ = junction to case thermal resistance ($^oC/W$)

$R_{\theta CA}$ = case to ambient thermal resistance ($^oC/W$)

$R_{\theta JC}$ is device related and cannot be influenced by the user. The user controls the thermal environment to change the case to ambient thermal resistance, $R_{\theta CA}$. For instance, the user can change the air flow around the device, add a heat sink, change the mounting arrangement on printed circuit board, or change the thermal dissipation on the printed circuit board surrounding the device. This description is most useful for packages with heat sinks where some 90% of the heat flow is through the case to the heat sink to ambient. For most packages, a better model is required.

A more accurate two-resistor thermal model can be constructed from the junction to board thermal resistance and the junction to case thermal resistance. The junction to case covers the situation where a heat sink will be used or where a substantial amount of heat is dissipated from the top of the package. The junction to board thermal resistance describes the thermal performance when most of the heat is conducted to the printed circuit board. This model can be used for either hand estimations or for a computational fluid dynamics (CFD) thermal model.

To determine the junction temperature of the device in the application after prototypes are available, the Thermal Characterization Parameter (Ψ_{JT}) can be used to determine the junction temperature with a measurement of the temperature at the top center of the package case using the following equation:

$$T_J = T_T + (\Psi_{JT} \times P_D) \qquad \textit{Eqn. 4}$$

where:

T_T = thermocouple temperature on top of the package (^oC)

Ψ_{JT} = thermal characterization parameter ($^oC/W$)

P_D = power dissipation in the package (W)

The thermal characterization parameter is measured per JESD51-2 specification using a 40-gauge type T thermocouple epoxied to the top center of the package case. The thermocouple should be positioned so that the thermocouple junction rests on the package. A small amount of epoxy is placed over the thermocouple junction and over about 1 mm of wire extending from the junction. The thermocouple wire is placed flat against the package case to avoid measurement errors caused by cooling effects of the thermocouple wire.

References:

Semiconductor Equipment and Materials International
3081 Zanker Road
San Jose, CA 95134
(408) 943-6900

MIL-SPEC and EIA/JESD (JEDEC) specifications are available from Global Engineering Documents at 800-854-7179 or 303-397-7956.

JEDEC specifications are available on the WEB at http://www.jedec.org.

1. C.E. Triplett and B. Joiner, “An Experimental Characterization of a 272 PBGA Within an Automotive Engine Controller Module,” Proceedings of SemiTherm, San Diego, 1998, pp. 47–54.
2. G. Kromann, S. Shidore, and S. Addison, “Thermal Modeling of a PBGA for Air-Cooled Applications,” Electronic Packaging and Production, pp. 53–58, March 1998.
3. B. Joiner and V. Adams, “Measurement and Simulation of Junction to Board Thermal Resistance and Its Application in Thermal Modeling,” Proceedings of SemiTherm, San Diego, 1999, pp. 212–220.

4.3 ESD Characteristics

Table 6. ESD Ratings[1, 2]

Characteristic	Symbol	Value	Unit
ESD for Human Body Model (HBM)		2000	V
HBM Circuit Description	R1	1500	Ohm
	C	100	pF
ESD for Field Induced Charge Model (FDCM)		750 (corner pins)	V
		250 (all other pins)	
Number of Pulses per pin: Positive Pulses (HBM) Negative Pulses (HBM)	 — —	 1 1	 — —
Interval of Pulses	—	1	second

1 All ESD testing is in conformity with CDF-AEC-Q100 Stress Test Qualification for Automotive Grade Integrated Circuits.

2 A device will be defined as a failure if after exposure to ESD pulses the device no longer meets the device specification requirements. Complete DC parametric and functional testing shall be performed per applicable device specification at room temperature followed by hot temperature, unless specified otherwise in the device specification.

4.4 VRC Electrical Specifications

Table 7. VRC Electrical Specifications

Spec	Characteristic	Symbol	Min	Max	Units
1	Current which can be sourced by V_{RCCTL}	I_V_{RCCTL}	6.25 µA	20 mA	—
2	Minimum Required Gain from external circuit: I_{DD} / I_V_{RCCTL} (@V_{DD} = 1.32 V)[1] –40°C 25°C 150°C	BETA	 50 50 50	 500	

1 Assumes “typical usage” currents which will vary with application.

4.5 DC Electrical Specifications

Table 8. DC Electrical Specifications

Spec	Characteristic	Symbol	Min	Max	Unit
1	Maximum Operating Temperature Range — Die Junction Temperature	T_J	–40.0	150.0	°C
2	3.3 V Clock Synthesizer Voltage[1]	V_{DDSYN}	3.0	3.6	V
3	3.3 V I/O Buffer Voltage[1]	V_{DD33}	3.0	3.6	V
4	3.3–5.0 V Voltage Regulator Reference Voltage[1] V_{RCSEL} = V_{SSA} V_{RCSEL} = V_{DDA}	V_{VRC}	 3.0 4.5	 3.6 5.5	V
5	3.3–5.0 V Analog Supply Voltage	V_{DDA}	maximum of 3.0 V or V_{VRC} – 0.1	5.5	V

4.7.1 I/O Pad V_{DD33} Current Specifications

The power consumption of the V_{DD33} supply is dependent on the usage of the pins on all I/O segments. The power consumption is the sum of all input and output pin V_{DD33} currents for all I/O segments. The output pin V_{DD33} current can be calculated from Table 11 based on the voltage, frequency, and load on all Pad F pins. The input pin V_{DD33} current can be calculated from Table 11 based on the voltage, frequency, and load on all Pad MH pins. Use linear scaling to calculate pin currents for voltage, frequency, and load parameters that fall outside the values given in Table 11.

Table 11. I/O Pad Average I_{DD33} Specifications[1]

Spec	Pad Type[2]	Symbol	Period (ns)	Load[3] (pF)	Drive Select	I_{DD33} Avg (µA)	I_{DD33} RMS (µA)
1	Slow	$I_{DRV\_SSR\_HV}$	100	50	11	0.8	235.7
2			200	50	01	0.04	87.4
3			800	50	00	0.06	47.4
4			800	200	00	0.009	47
5	Medium	$I_{DRV\_MSR\_HV}$	40	50	11		
6			100	50	01	0.11	76.5
7			500	50	00	0.02	56.2
8			500	200	00	0.01	56.2
9	Input	$I_{DRV\_I\_HV}$	7	0.5	N/A		

1 These are typical values that are estimated from simulation and not tested. Currents apply to output pins only.

2 Slow = SH or SHA; Medium = MH or MHA; Fast = F; Input = IHA. See Table 2.

3 All loads are lumped.

Table 12. I_{DD33} Pad Average DC Current[1]

Spec	Pad Type[2]	Symbol	Period (ns)	Load[3] (pF)	V_{DD33} (V)	V_{DDE} (V)	Drive Select	I_{DD33} Avg (µA)	I_{DD33} RMS (µA)
1	Fast	I_{DRV_FC}	10	50	3.6	3.6	11	3.32	11.77
2			10	30	3.6	3.6	10	2.28	7.07
3			10	20	3.6	3.6	01	1.73	5.75
4			10	10	3.6	3.6	00	1.39	4.77
5			10	50	3.6	2.75	11	2.3	7.81
6			10	30	3.6	2.75	10	1.64	4.96
7			10	20	3.6	2.75	01	1.37	4.31
8			10	10	3.6	2.75	00	1.06	4.09

1 These are typical values that are estimated from simulation and not tested. Currents apply to output pins only.

2 Slow = SH or SHA; Medium = MH or MHA; Fast = F; Input = IHA. See Table 2.

3 All loads are lumped.

Table 17. 5V Low Frequency (128 kHz) Internal RC Oscillator

Spec	Characteristic	Symbol	Range	Min	Typ	Max	Unit
1	Frequency before trim[1]	F_{ut128}	35%	83.2	128	172.8	kHz
2	Frequency after loading factory trim[2]	F_{t128}	7%	119.0	128	137.0	kHz
3	Application trim resolution[3]	T_{s128}	—	—	—	±2	%
4	Application frequency trim step[3]	F_{s128}	—	—	4	—	kHz
5	Startup Time	S_{t128}	—	—	—	100	µs

1 Across process, voltage, and temperature.

2 Across voltage and temperature.

3 Fixed voltage and temperature.

4.10 FMPLL Electrical Characteristics

Table 18. FMPLL Electrical Specifications[1]

Spec	Characteristic	Symbol	Min	Max	Unit
1	System Frequency[2]	f_{SYS}	—	116	MHz
2	PLL Reference Frequency Range	f_{REF}	4	40	MHz
3	PLL Frequency	f_{PLL}	$\frac{f_{vco(min)}}{(ERFD+1)}$		MHz
4	Loss of Reference Frequency [3]	f_{LOR}	100	2000	kHz
5	Self Clocked Mode Frequency	f_{SCM}	16	64	MHz
6	PLL Lock Time[4]	t_{LPLL}	—	400	µs
7	Duty Cycle of Reference	t_{DC}	40	60	%
8	Frequency un-LOCK Range	f_{UL}	–4.0	4.0	% f_{SYS}
9	Frequency LOCK Range	f_{LCK}	–2.0	2.0	% f_{SYS}
10	CLKOUT Period Jitter,[5] Measured at f_{SYS} Max Cycle-to-cycle Jitter	C_{Jitter}	–5	5	%f_{SYS}
11	CLKOUT Jitter at ≥ 50 µs period	C_{Jitter}	–250	250	ns
12	Peak-to-Peak Frequency Modulation Range Limit [6,7] (f_{SYS}Max must not be exceeded)	C_{mod}	0	4	%f_{SYS}
13	FM Depth Tolerance[8]	C_{mod_err}	–0.50	0.50	%f_{SYS}
14	VCO Frequency[9]	f_{VCO}	192	600	MHz
15	Modulation Rate Limits[10]	f_{MOD}	0.400	1	MHz

1 V_{DDSYN} = 3.0 V to 3.6 V, V_{SS} = V_{SSSYN} = 0 V, T_A = T_L to T_H.

2 The maximum frequency value is with frequency modulation disabled. If frequency modulation is enabled, the maximum frequency value should be de-rated by the percentage of modulation enabled so that the maximum frequency is not exceeded.

3 "Loss of Reference Frequency" is the reference frequency detected internally, which transitions the PLL into self clocked mode.

4 This specification applies to the period required for the PLL to re-lock after changing the MFD frequency control bits in the synthesizer control register (SYNCR). From power up with crystal oscillator reference, lock time will be additive with crystal startup time.

5 Values are with frequency modulation disabled. If frequency modulation is enabled, jitter is the sum of C_{jitter} + C_{mod}.

6 Modulation depth selected must not result in f_{PLL} value greater than the f_{PLL} maximum specified value.

7 Maximum and minimum variations from programmed modulation depth are 2%, 3%, and 4% peak-to-peak. Use only these settings.

8 Depth tolerance is the programmed modulation depth ±0.25% of f_{SYS}.

9 See the Block Guide for VCO frequency synthesis equations.

10 Modulation rates less than 400 kHz will result in exceedingly long FM calibration durations. Modulation rates greater than 1 MHz will result in reduced calibration accuracy.

4.11 ADC Electrical Characteristics

Table 19. ADC Conversion Specifications (Operating)

Spec	Characteristic	Symbol	Min	Max	Unit
1	Analog High Reference Voltage	V_{RH}	V_{DDA} – 0.5	V_{DDA}	V
2	Analog Low Reference Voltage	V_{RL}	0	0.5	V
3	Analog Input Voltage	AV_{IN}	V_{RL}	V_{RH}	V
4	Sampling Frequency	F_S	—	1.53	MHz
5	Maximum ADC Clock Frequency	F_{MAX}	—	60	MHz
6	Sampling Time V_{DDA} = 3.0 V – 3.6 V V_{DDA} > 3.6 V – 5.5 V	t_S	 250 125	—	ns
7	Differential Non Linearity	DNL	–1.0	1.0	LSB
8	Integral Non Linearity	INL	–1.5	1.5	LSB
9	Offset Error	OFS	–1.0	1.0	LSB
10	Gain Error	GNE	–2.0	2.0	LSB
11	Total Unadjusted Error [1]	TUE	–2.0	2.0	LSB

1 TUE assumes no pin activity on pins adjacent to analog channel or output driver activity on corresponding V_{DDE} segment.

4.12 Flash Memory Electrical Characteristics

Table 20. Flash Program and Erase Specifications[1]

Spec	Characteristic	Symbol	Min	Initial Max[2]	Max[3]	Unit
1	Double Word (64 bits) Program Time[4]	$t_{dwprogram}$	—	—	500	µs
2	Page (128 bits and 256 bits) Program Time[4]	$t_{pprogram}$	—	160	500	µs
3	16 KB Block Pre-program and Erase Time	$t_{16kpperase}$	—	1000	5000	ms
4	64 KB Block Pre-program and Erase Time	$t_{64kpperase}$	—	1800	5000	ms
5	128 KB Block Pre-program and Erase Time	$t_{128kpperase}$	—	2600	7500	ms

4.14 AC Timing

4.14.1 Reset and Boot Configuration Pins

Table 24. Reset and Boot Configuration Timing

Spec	Characteristic	Symbol	Min	Max	Unit
1	$\overline{\text{RESET}}$ Pulse Width	t_{RPW}	150	—	ns
2	BOOTCFG Setup Time after $\overline{\text{RESET}}$ Valid	t_{RCSU}	—	100	µs
3	BOOTCFG Hold Time from $\overline{\text{RESET}}$ Valid	t_{RCH}	0	—	µs

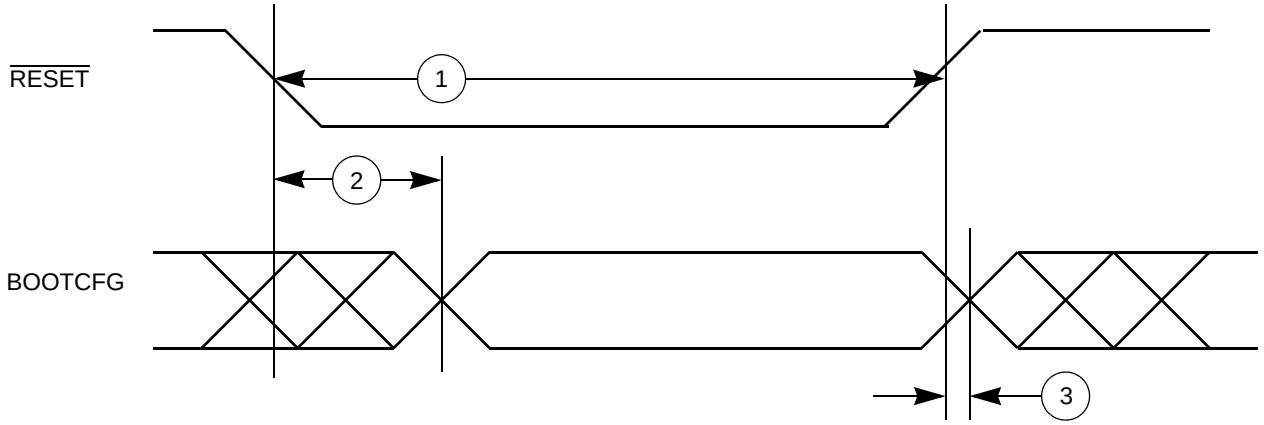


Figure 7. Reset and Boot Configuration Timing

4.14.2 External Interrupt (IRQ) and Non-Maskable Interrupt (NMI) Pins

Table 25. IRQ/NMI Timing

Spec	Characteristic	Symbol	Min	Max	Unit
1	IRQ/NMI Pulse Width Low	t_{IPWL}	3	—	t_{SYS}
2	IRQ/NMI Pulse Width High	T_{IPWH}	3	—	t_{SYS}
3	IRQ/NMI Edge to Edge Time[1]	t_{ICYC}	6	—	t_{SYS}

[1] Applies when IRQ/NMI pins are configured for rising edge or falling edge events, but not both.

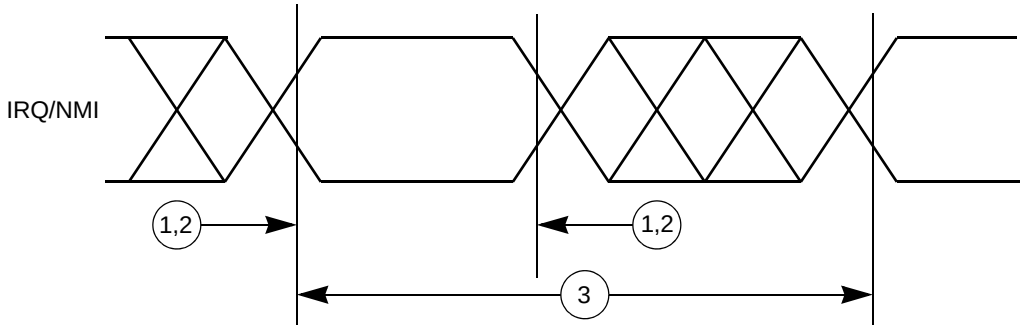


Figure 8. IRQ and NMI Timing

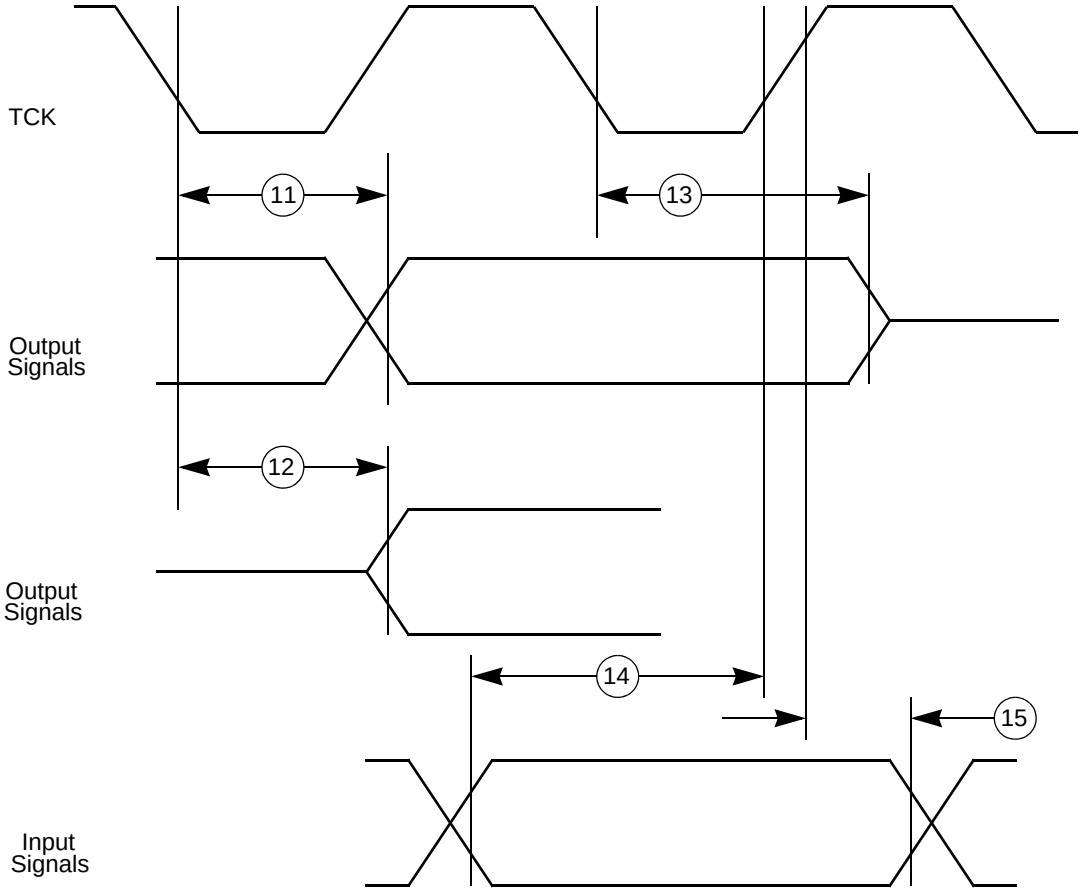


Figure 12. JTAG Boundary Scan Timing

Table 31. MLB Timing for MLB Speed 256 Fs or 512 Fs (continued)

Spec	Parameter	Symbol	Min	Typ	Max	Unit	Comments
10	MLBSIG/MLBDAT output high impedance from MLBCLK low	t_{mcfdz}	0	—	t_{mckl}	ns	
11	Bus Hold time[3]	t_{mdzh}	4	—	—	ns	
12	MLBSIG/MLBDAT output valid from MLBCLK rising	t_{mcrdv}	—	—	8	ns	

- Ground = 0.0V
- Load Capacitance = 60 pF, SIU_PCR144–SIU_PCR146[DSC] = 0b11.
- MLB speed of 256 Fs or 512 Fs (Fs = 48 kHz)
  Unless otherwise noted, all timing parameters are specified from the valid voltage threshold in Table 30.

1 The Controller can shut off MLBCLK to place MLB in a low-power state.

2 Pulse width variation is measured at 1.25 V by triggering on one edge of MLBCLK and measuring the spread on the other edge, measured in ns peak-to-peak (ns p-p).

3 The board must be designed to insure that the high-impedance bus does not leave the logic state of the final driven bit for this time period. Therefore, coupling must be minimized while meeting the maximum capacitive load listed.

Table 32. MLB Timing for MLB Speed 1024 Fs

Spec	Parameter	Symbol	Min	Typ	Max	Unit	Comments
1	MLBCLK Operating Frequency[1]	f_{mck}	45.056 — — —	— 49.152 — —	— — 49.2544 51.200	MHz	1024 Fs at 44.0 kHz 1024 Fs at 48.0 kHz 1024 Fs at 48.1 kHz 1024 Fs PLL unlocked
2	MLBCLK rise time	t_{mckr}	—	—	1	ns	V_{IL} to V_{IH}
3	MLBCLK fall time	t_{mckf}	—	—	1	ns	V_{IH} to V_{IL}
4	MLBCLK cycle time	t_{mckc}	—	20.3	—	ns	V_{IL} to V_{IH}
5	MLBCLK low time	t_{mckl}	6.5 6.1	7.7 7.3	—	ns	1024 Fs PLL unlocked
6	MLBCLK high time	t_{mckh}	9.7 9.3	10.6 10.2	—	ns	1024 Fs PLL unclocked
7	MLBCLK pulse width variation[2]	t_{mpwv}	—	—	0.7	ns p-p	
8	MLBSIG/MLBDAT input valid to MLBCLK falling	t_{dsmcf}	1	—	—	ns	
9	MLBSIG/MLBDAT input hold from MLBCLK low	t_{dhmcf}	0	—	—	ns	
10	MLBSIG/MLBDAT output high impedance from MLBCLK low	t_{mcfdz}	0	—	t_{mckl}	ns	
11	Bus Hold time[3]	t_{mdzh}	2	—	—	ns	
12	MLBSIG/MLBDAT output valid from MLBCLK rising	t_{mcrdv}	—	—	7	ns	

- Ground = 0.0V
- Load Capacitance = 40 pF, SIU_PCR144–SIU_PCR146[DSC] = 0b00.
- MLB speed = 1024Fs (Fs = 48 kHz)
- Unless otherwise noted, timing parameters are specified from the valid voltage threshold in Table 30.

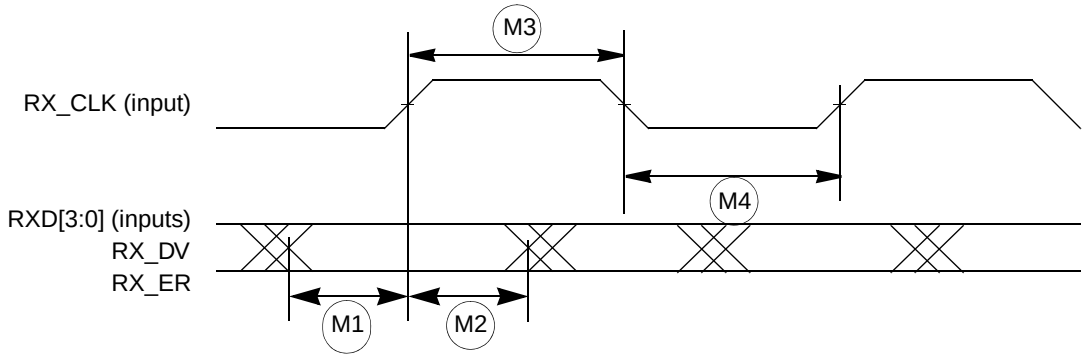


Figure 26. MII Receive Signal Timing Diagram

4.14.8.2 MII Transmit Signal Timing (TXD[3:0], TX_EN, TX_ER, TX_CLK)

The transmitter functions correctly up to a TX_CLK maximum frequency of 25 MHz +1%. There is no minimum frequency requirement. In addition, the system clock frequency must exceed four times the TX_CLK frequency.

The transmit outputs (TXD[3:0], TX_EN, TX_ER) can be programmed to transition from either the rising or falling edge of TX_CLK, and the timing is the same in either case. This options allows the use of non-compliant MII PHYs.

Refer to the Ethernet chapter for details of this option and how to enable it.

Table 34. MII Transmit Signal Timing[1]

Spec	Characteristic	Min	Max	Unit
M5	TX_CLK to TXD[3:0], TX_EN, TX_ER invalid	5	—	ns
M6	TX_CLK to TXD[3:0], TX_EN, TX_ER valid	—	25	ns
M7	TX_CLK pulse width high	35%	65%	TX_CLK period
M8	TX_CLK pulse width low	35%	65%	TX_CLK period

1 Output pads configured with SRC = 0b11.

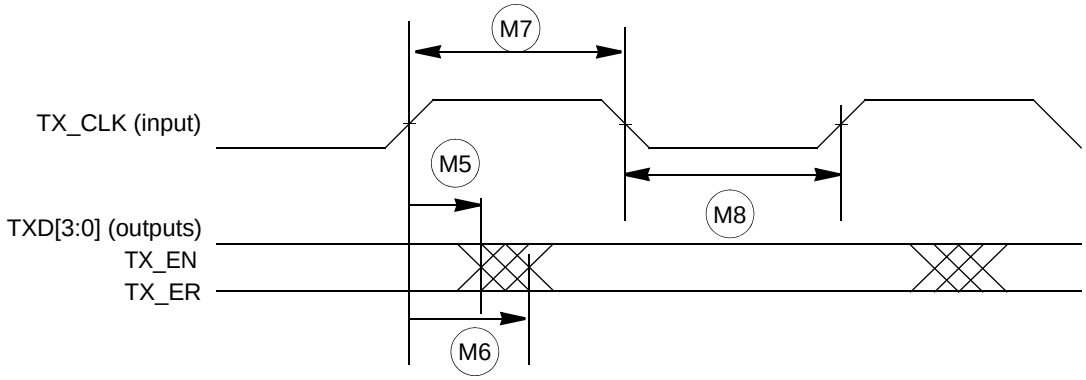
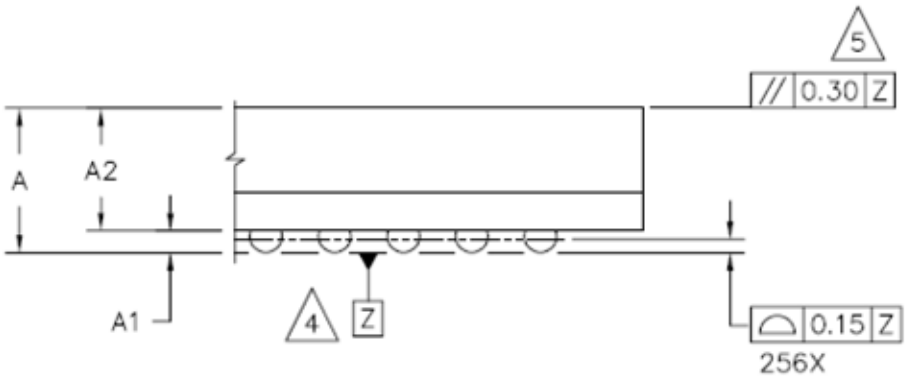


Figure 27. MII Transmit Signal Timing Diagram



DETAIL K
ROTATED 90° CLOCKWISE

DIM	MIN	MAX
A	1.25	1.60
A1	0.27	0.47
A2	1.16 REF	
b	0.40	0.60
D	17.00 BSC	
E	17.00 BSC	
e	1.00 BSC	
S	0.50 BSC	

NOTES

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DIMENSION b IS MEASURED AT THE MAXIMUM SOLDER BALL DIAMETER, PARALLEL TO DATUM PLANE Z.
4. DATUM Z (SEATING PLANE) IS DEFINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.

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Figure 33. 256 MAPBGA Package Detail

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