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K51 Sub-Family

Supports: MK51DX256CLL7,
MK51DX128CMC7, MK51DX256CMC7

Features

- Operating Characteristics
 - Voltage range: 1.71 to 3.6 V
 - Flash write voltage range: 1.71 to 3.6 V
 - Temperature range (ambient): -40 to 85°C
- Clocks
 - 3 to 32 MHz crystal oscillator
 - 32 kHz crystal oscillator
 - Multi-purpose clock generator
- System peripherals
 - Multiple low-power modes to provide power optimization based on application requirements
 - 16-channel DMA controller, supporting up to 63 request sources
 - External watchdog monitor
 - Software watchdog
 - Low-leakage wakeup unit
- Security and integrity modules
 - Hardware CRC module to support fast cyclic redundancy checks
 - 128-bit unique identification (ID) number per chip
- Human-machine interface
 - Segment LCD controller supporting up to 36 frontplanes and 8 backplanes, or 40 frontplanes and 4 backplanes, depending on the package size
 - Low-power hardware touch sensor interface (TSI)
 - General-purpose input/output
- Analog modules
 - Two 16-bit SAR ADCs
 - Programmable gain amplifier (PGA) (up to x64) integrated into each ADC
 - 12-bit DAC
 - Two operational amplifiers
 - One transimpedance amplifier
 - Three analog comparators (CMP) containing a 6-bit DAC and programmable reference input
 - Voltage reference
- Timers
 - Programmable delay block
 - Eight-channel motor control/general purpose/PWM timer
 - Two 2-channel quadrature decoder/general purpose timers
 - Periodic interrupt timers
 - 16-bit low-power timer
 - Carrier modulator transmitter
 - Real-time clock
- Communication interfaces
 - USB full-/low-speed On-the-Go controller with on-chip transceiver
 - Two SPI modules
 - Two I2C modules
 - Five UART modules
 - I2S module

K51P100M72SF1



Table of Contents

1	Ordering parts.....	4	6.1	Core modules.....	23
1.1	Determining valid orderable parts.....	4	6.1.1	Debug trace timing specifications.....	23
2	Part identification.....	4	6.1.2	JTAG electricals.....	23
2.1	Description.....	4	6.2	System modules.....	26
2.2	Format.....	4	6.3	Clock modules.....	26
2.3	Fields.....	4	6.3.1	MCG specifications.....	26
2.4	Example.....	5	6.3.2	Oscillator electrical specifications.....	28
3	Terminology and guidelines.....	5	6.3.3	32 kHz Oscillator Electrical Characteristics.....	31
3.1	Definition: Operating requirement.....	5	6.4	Memories and memory interfaces.....	31
3.2	Definition: Operating behavior.....	6	6.4.1	Flash electrical specifications.....	31
3.3	Definition: Attribute.....	6	6.4.2	EzPort Switching Specifications.....	36
3.4	Definition: Rating.....	7	6.5	Security and integrity modules.....	37
3.5	Result of exceeding a rating.....	7	6.6	Analog.....	37
3.6	Relationship between ratings and operating requirements.....	7	6.6.1	ADC electrical specifications.....	37
3.7	Guidelines for ratings and operating requirements.....	8	6.6.2	CMP and 6-bit DAC electrical specifications.....	44
3.8	Definition: Typical value.....	8	6.6.3	12-bit DAC electrical characteristics.....	47
3.9	Typical value conditions.....	9	6.6.4	Op-amp electrical specifications.....	50
4	Ratings.....	10	6.6.5	Transimpedance amplifier electrical specifications — full range.....	51
4.1	Thermal handling ratings.....	10	6.6.6	Transimpedance amplifier electrical specifications — limited range.....	52
4.2	Moisture handling ratings.....	10	6.6.7	Voltage reference electrical specifications.....	53
4.3	ESD handling ratings.....	10	6.7	Timers.....	54
4.4	Voltage and current operating ratings.....	10	6.8	Communication interfaces.....	54
5	General.....	11	6.8.1	USB electrical specifications.....	54
5.1	AC electrical characteristics.....	11	6.8.2	USB DCD electrical specifications.....	55
5.2	Nonswitching electrical specifications.....	11	6.8.3	USB VREG electrical specifications.....	55
5.2.1	Voltage and current operating requirements.....	12	6.8.4	DSPI switching specifications (limited voltage range).....	55
5.2.2	LVD and POR operating requirements.....	12	6.8.5	DSPI switching specifications (full voltage range).....	57
5.2.3	Voltage and current operating behaviors.....	13	6.8.6	I2C switching specifications.....	59
5.2.4	Power mode transition operating behaviors.....	14	6.8.7	UART switching specifications.....	59
5.2.5	Power consumption operating behaviors.....	15	6.8.8	I2S/SAI Switching Specifications.....	59
5.2.6	Designing with radiated emissions in mind.....	19	6.9	Human-machine interfaces (HMI).....	63
5.2.7	Capacitance attributes.....	19	6.9.1	TSI electrical specifications.....	63
5.3	Switching specifications.....	20	6.9.2	LCD electrical characteristics.....	64
5.3.1	Device clock specifications.....	20	7	Dimensions.....	65
5.3.2	General switching specifications.....	20	7.1	Obtaining package dimensions.....	65
5.4	Thermal specifications.....	21	8	Pinout.....	66
5.4.1	Thermal operating requirements.....	21	8.1	K51 Signal Multiplexing and Pin Assignments.....	66
5.4.2	Thermal attributes.....	22			
6	Peripheral operating requirements and behaviors.....	23			



8.2 K51 Pinouts.....71

9 Revision History.....73

1 Ordering parts

1.1 Determining valid orderable parts

Valid orderable part numbers are provided on the web. To determine the orderable part numbers for this device, go to www.freescale.com and perform a part number search for the following device numbers: PK51 and MK51.

2 Part identification

2.1 Description

Part numbers for the chip have fields that identify the specific part. You can use the values of these fields to determine the specific part you have received.

2.2 Format

Part numbers for this device have the following format:

Q K## A M FFF R T PP CC N

2.3 Fields

This table lists the possible values for each field in the part number (not all combinations are valid):

Field	Description	Values
Q	Qualification status	<ul style="list-style-type: none"> M = Fully qualified, general market flow P = Prequalification
K##	Kinetis family	<ul style="list-style-type: none"> K51
A	Key attribute	<ul style="list-style-type: none"> D = Cortex-M4 w/ DSP F = Cortex-M4 w/ DSP and FPU
M	Flash memory type	<ul style="list-style-type: none"> N = Program flash only X = Program flash and FlexMemory

Table continues on the next page...

Field	Description	Values
FFF	Program flash memory size	<ul style="list-style-type: none"> • 32 = 32 KB • 64 = 64 KB • 128 = 128 KB • 256 = 256 KB • 512 = 512 KB • 1M0 = 1 MB
R	Silicon revision	<ul style="list-style-type: none"> • Z = Initial • (Blank) = Main • A = Revision after main
T	Temperature range (°C)	<ul style="list-style-type: none"> • V = -40 to 105 • C = -40 to 85
PP	Package identifier	<ul style="list-style-type: none"> • FM = 32 QFN (5 mm x 5 mm) • FT = 48 QFN (7 mm x 7 mm) • LF = 48 LQFP (7 mm x 7 mm) • LH = 64 LQFP (10 mm x 10 mm) • MP = 64 MAPBGA (5 mm x 5 mm) • LK = 80 LQFP (12 mm x 12 mm) • LL = 100 LQFP (14 mm x 14 mm) • MC = 121 MAPBGA (8 mm x 8 mm) • LQ = 144 LQFP (20 mm x 20 mm) • MD = 144 MAPBGA (13 mm x 13 mm) • MJ = 256 MAPBGA (17 mm x 17 mm)
CC	Maximum CPU frequency (MHz)	<ul style="list-style-type: none"> • 5 = 50 MHz • 7 = 72 MHz • 10 = 100 MHz • 12 = 120 MHz • 15 = 150 MHz
N	Packaging type	<ul style="list-style-type: none"> • R = Tape and reel • (Blank) = Trays

2.4 Example

This is an example part number:

MK51DN512ZVMD10

3 Terminology and guidelines

3.1 Definition: Operating requirement

An *operating requirement* is a specified value or range of values for a technical characteristic that you must guarantee during operation to avoid incorrect operation and possibly decreasing the useful life of the chip.

3.1.1 Example

This is an example of an operating requirement, which you must meet for the accompanying operating behaviors to be guaranteed:

Symbol	Description	Min.	Max.	Unit
V _{DD}	1.0 V core supply voltage	0.9	1.1	V

3.2 Definition: Operating behavior

An *operating behavior* is a specified value or range of values for a technical characteristic that are guaranteed during operation if you meet the operating requirements and any other specified conditions.

3.2.1 Example

This is an example of an operating behavior, which is guaranteed if you meet the accompanying operating requirements:

Symbol	Description	Min.	Max.	Unit
I _{WP}	Digital I/O weak pullup/pulldown current	10	130	μA

3.3 Definition: Attribute

An *attribute* is a specified value or range of values for a technical characteristic that are guaranteed, regardless of whether you meet the operating requirements.

3.3.1 Example

This is an example of an attribute:

Symbol	Description	Min.	Max.	Unit
CIN_D	Input capacitance: digital pins	—	7	pF

3.4 Definition: Rating

A *rating* is a minimum or maximum value of a technical characteristic that, if exceeded, may cause permanent chip failure:

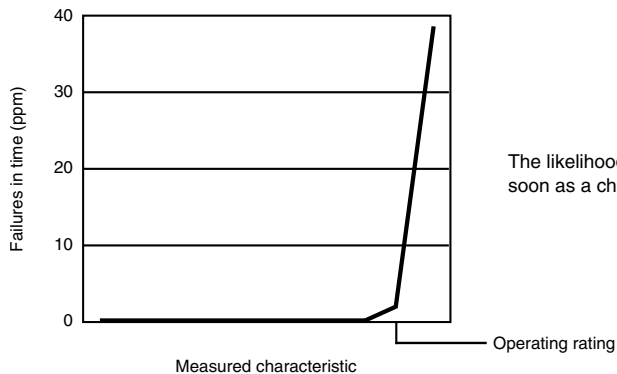
- *Operating ratings* apply during operation of the chip.
- *Handling ratings* apply when the chip is not powered.

3.4.1 Example

This is an example of an operating rating:

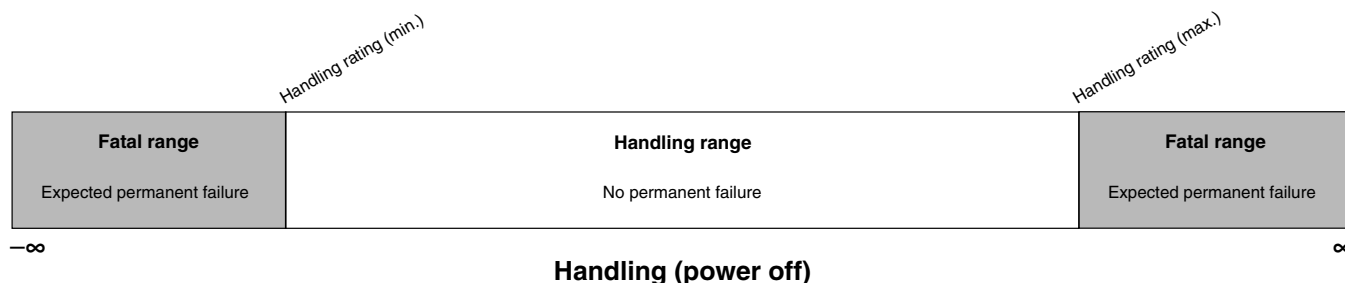
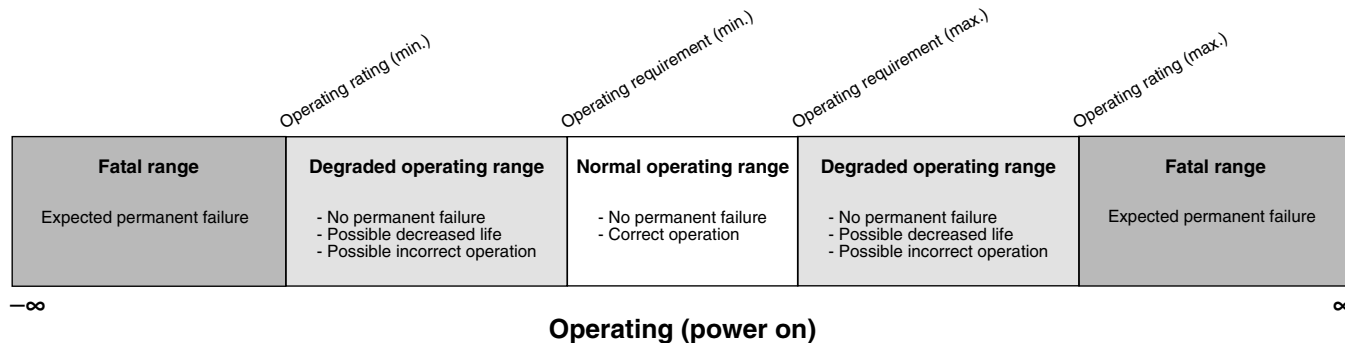
Symbol	Description	Min.	Max.	Unit
V _{DD}	1.0 V core supply voltage	-0.3	1.2	V

3.5 Result of exceeding a rating



The likelihood of permanent chip failure increases rapidly as soon as a characteristic begins to exceed one of its operating ratings.

3.6 Relationship between ratings and operating requirements



3.7 Guidelines for ratings and operating requirements

Follow these guidelines for ratings and operating requirements:

- Never exceed any of the chip’s ratings.
- During normal operation, don’t exceed any of the chip’s operating requirements.
- If you must exceed an operating requirement at times other than during normal operation (for example, during power sequencing), limit the duration as much as possible.

3.8 Definition: Typical value

A *typical value* is a specified value for a technical characteristic that:

- Lies within the range of values specified by the operating behavior
- Given the typical manufacturing process, is representative of that characteristic during operation when you meet the typical-value conditions or other specified conditions

Typical values are provided as design guidelines and are neither tested nor guaranteed.

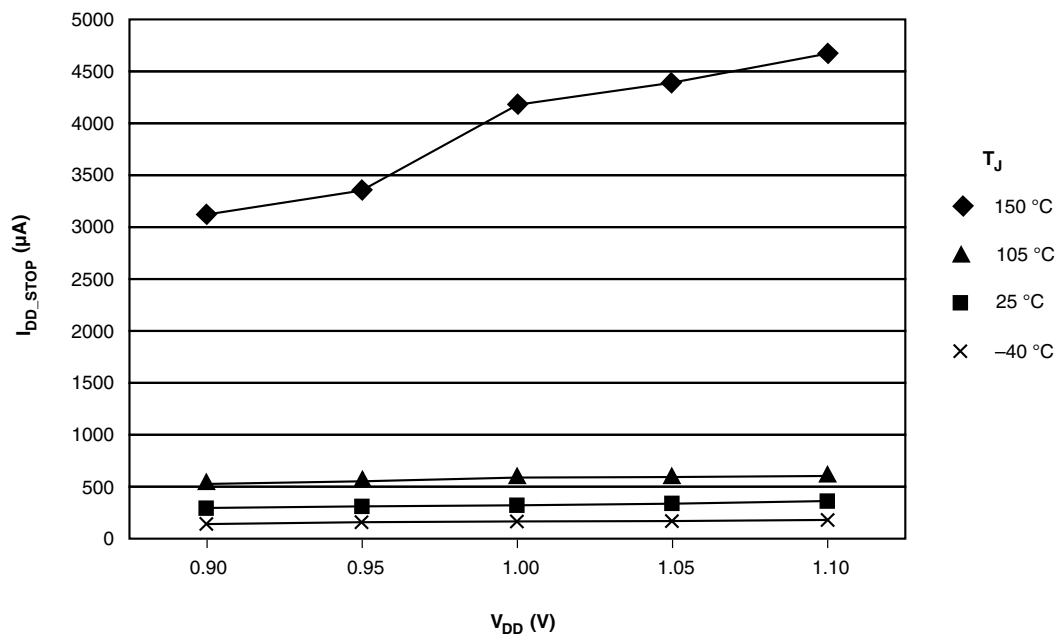
3.8.1 Example 1

This is an example of an operating behavior that includes a typical value:

Symbol	Description	Min.	Typ.	Max.	Unit
I_{WP}	Digital I/O weak pullup/pulldown current	10	70	130	μA

3.8.2 Example 2

This is an example of a chart that shows typical values for various voltage and temperature conditions:



3.9 Typical value conditions

Typical values assume you meet the following conditions (or other conditions as specified):

Symbol	Description	Value	Unit
T_A	Ambient temperature	25	$^{\circ}\text{C}$
V_{DD}	3.3 V supply voltage	3.3	V

4 Ratings

4.1 Thermal handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
T _{STG}	Storage temperature	-55	150	°C	1
T _{SDR}	Solder temperature, lead-free	—	260	°C	2

1. Determined according to JEDEC Standard JESD22-A103, *High Temperature Storage Life*.
2. Determined according to IPC/JEDEC Standard J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices*.

4.2 Moisture handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
MSL	Moisture sensitivity level	—	3	—	1

1. Determined according to IPC/JEDEC Standard J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices*.

4.3 ESD handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
V _{HBM}	Electrostatic discharge voltage, human body model	-2000	+2000	V	1
V _{CDM}	Electrostatic discharge voltage, charged-device model	-500	+500	V	2
I _{LAT}	Latch-up current at ambient temperature of 105°C	-100	+100	mA	

1. Determined according to JEDEC Standard JESD22-A114, *Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)*.
2. Determined according to JEDEC Standard JESD22-C101, *Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components*.

4.4 Voltage and current operating ratings

Symbol	Description	Min.	Max.	Unit
V _{DD}	Digital supply voltage	-0.3	3.8	V

Table continues on the next page...

Symbol	Description	Min.	Max.	Unit
I_{DD}	Digital supply current	—	185	mA
V_{DIO}	Digital input voltage (except \overline{RESET} , EXTAL, and XTAL)	-0.3	5.5	V
V_{AIO}	Analog ¹ , \overline{RESET} , EXTAL, and XTAL input voltage	-0.3	$V_{DD} + 0.3$	V
I_D	Maximum current single pin limit (applies to all digital pins)	-25	25	mA
V_{DDA}	Analog supply voltage	$V_{DD} - 0.3$	$V_{DD} + 0.3$	V
V_{USB_DP}	USB_DP input voltage	-0.3	3.63	V
V_{USB_DM}	USB_DM input voltage	-0.3	3.63	V
VREGIN	USB regulator input	-0.3	6.0	V
V_{BAT}	RTC battery supply voltage	-0.3	3.8	V

1. Analog pins are defined as pins that do not have an associated general purpose I/O port function.

5 General

5.1 AC electrical characteristics

Unless otherwise specified, propagation delays are measured from the 50% to the 50% point, and rise and fall times are measured at the 20% and 80% points, as shown in the following figure.

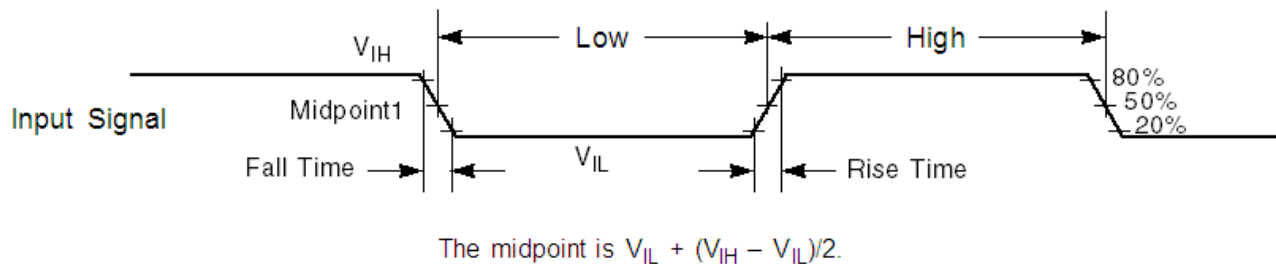


Figure 1. Input signal measurement reference

All digital I/O switching characteristics assume:

1. output pins
 - have $C_L=30\text{pF}$ loads,
 - are configured for fast slew rate ($\text{PORTx_PCRn[SRE]}=0$), and
 - are configured for high drive strength ($\text{PORTx_PCRn[DSE]}=1$)
2. input pins
 - have their passive filter disabled ($\text{PORTx_PCRn[PFE]}=0$)

5.2 Nonswitching electrical specifications

5.2.1 Voltage and current operating requirements

Table 1. Voltage and current operating requirements

Symbol	Description	Min.	Max.	Unit	Notes
V_{DD}	Supply voltage	1.71	3.6	V	
V_{DDA}	Analog supply voltage	1.71	3.6	V	
$V_{DD} - V_{DDA}$	V_{DD} -to- V_{DDA} differential voltage	-0.1	0.1	V	
$V_{SS} - V_{SSA}$	V_{SS} -to- V_{SSA} differential voltage	-0.1	0.1	V	
V_{BAT}	RTC battery supply voltage	1.71	3.6	V	
V_{IH}	Input high voltage <ul style="list-style-type: none"> $2.7\text{ V} \leq V_{DD} \leq 3.6\text{ V}$ $1.7\text{ V} \leq V_{DD} \leq 2.7\text{ V}$ 	$0.7 \times V_{DD}$ $0.75 \times V_{DD}$	— —	V V	
V_{IL}	Input low voltage <ul style="list-style-type: none"> $2.7\text{ V} \leq V_{DD} \leq 3.6\text{ V}$ $1.7\text{ V} \leq V_{DD} \leq 2.7\text{ V}$ 	— —	$0.35 \times V_{DD}$ $0.3 \times V_{DD}$	V V	
V_{HYS}	Input hysteresis	$0.06 \times V_{DD}$	—	V	
I_{CDIO}	Digital pin negative DC injection current — single pin <ul style="list-style-type: none"> $V_{IN} < V_{SS}-0.3\text{V}$ 	-5	—	mA	1
I_{CAIO}	Analog ² , EXTAL, and XTAL pin DC injection current — single pin <ul style="list-style-type: none"> $V_{IN} < V_{SS}-0.3\text{V}$ (Negative current injection) $V_{IN} > V_{DD}+0.3\text{V}$ (Positive current injection) 	-5 —	— +5	mA	3
I_{Ccont}	Contiguous pin DC injection current — regional limit, includes sum of negative injection currents or sum of positive injection currents of 16 contiguous pins <ul style="list-style-type: none"> Negative current injection Positive current injection 	-25 —	— +25	mA	
V_{RAM}	V_{DD} voltage required to retain RAM	1.2	—	V	
V_{RFVBAT}	V_{BAT} voltage required to retain the VBAT register file	V_{POR_VBAT}	—	V	

- All 5 V tolerant digital I/O pins are internally clamped to V_{SS} through a ESD protection diode. There is no diode connection to V_{DD} . If V_{IN} greater than V_{DIO_MIN} ($=V_{SS}-0.3\text{V}$) is observed, then there is no need to provide current limiting resistors at the pads. If this limit cannot be observed then a current limiting resistor is required. The negative DC injection current limiting resistor is calculated as $R=(V_{DIO_MIN}-V_{IN})/|I_{IC}|$.
- Analog pins are defined as pins that do not have an associated general purpose I/O port function.
- All analog pins are internally clamped to V_{SS} and V_{DD} through ESD protection diodes. If V_{IN} is greater than V_{AIO_MIN} ($=V_{SS}-0.3\text{V}$) and V_{IN} is less than V_{AIO_MAX} ($=V_{DD}+0.3\text{V}$) is observed, then there is no need to provide current limiting resistors at the pads. If these limits cannot be observed then a current limiting resistor is required. The negative DC injection current limiting resistor is calculated as $R=(V_{AIO_MIN}-V_{IN})/|I_{IC}|$. The positive injection current limiting resistor is calculated as $R=(V_{IN}-V_{AIO_MAX})/|I_{IC}|$. Select the larger of these two calculated resistances.

5.2.2 LVD and POR operating requirements

Table 2. V_{DD} supply LVD and POR operating requirements

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V _{POR}	Falling VDD POR detect voltage	0.8	1.1	1.5	V	
V _{LVDH}	Falling low-voltage detect threshold — high range (LVDV=01)	2.48	2.56	2.64	V	
V _{LVW1H}	Low-voltage warning thresholds — high range					1
	• Level 1 falling (LVWV=00)	2.62	2.70	2.78	V	
V _{LVW2H}	• Level 2 falling (LVWV=01)	2.72	2.80	2.88	V	
V _{LVW3H}	• Level 3 falling (LVWV=10)	2.82	2.90	2.98	V	
V _{LVW4H}	• Level 4 falling (LVWV=11)	2.92	3.00	3.08	V	
V _{HYSH}	Low-voltage inhibit reset/recover hysteresis — high range	—	±80	—	mV	
V _{LVDL}	Falling low-voltage detect threshold — low range (LVDV=00)	1.54	1.60	1.66	V	
V _{LVW1L}	Low-voltage warning thresholds — low range					1
	• Level 1 falling (LVWV=00)	1.74	1.80	1.86	V	
V _{LVW2L}	• Level 2 falling (LVWV=01)	1.84	1.90	1.96	V	
V _{LVW3L}	• Level 3 falling (LVWV=10)	1.94	2.00	2.06	V	
V _{LVW4L}	• Level 4 falling (LVWV=11)	2.04	2.10	2.16	V	
V _{HYSL}	Low-voltage inhibit reset/recover hysteresis — low range	—	±60	—	mV	
V _{BG}	Bandgap voltage reference	0.97	1.00	1.03	V	
t _{LPO}	Internal low power oscillator period — factory trimmed	900	1000	1100	µs	

1. Rising thresholds are falling threshold + hysteresis voltage

Table 3. VBAT power operating requirements

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V _{POR_VBAT}	Falling VBAT supply POR detect voltage	0.8	1.1	1.5	V	

5.2.3 Voltage and current operating behaviors

Table 4. Voltage and current operating behaviors

Symbol	Description	Min.	Max.	Unit	Notes
V _{OH}	Output high voltage — high drive strength				
	• 2.7 V ≤ V _{DD} ≤ 3.6 V, I _{OH} = -9mA	V _{DD} - 0.5	—	V	
	• 1.71 V ≤ V _{DD} ≤ 2.7 V, I _{OH} = -3mA	V _{DD} - 0.5	—	V	
	Output high voltage — low drive strength				
V _{OL}	Output low voltage — high drive strength				
	• 2.7 V ≤ V _{DD} ≤ 3.6 V, I _{OL} = 9mA	—	0.5	V	
	• 1.71 V ≤ V _{DD} ≤ 2.7 V, I _{OL} = 3mA	—	0.5	V	
	Output low voltage — low drive strength				
I _{OLT}	Output low current total for all ports	—	100	mA	
	• 2.7 V ≤ V _{DD} ≤ 3.6 V, I _{OL} = 2mA	—	0.5	V	
	• 1.71 V ≤ V _{DD} ≤ 2.7 V, I _{OL} = 0.6mA	—	0.5	V	
	Output low current total for all ports	—	100	mA	
I _{IN}	Input leakage current (per pin) for full temperature range except TRI0_DM, TRI0_DP, TRI1_DM, TRI1_DP	—	1	μA	1
I _{IN}	Input leakage current (per pin) at 25°C except TRI0_DM, TRI0_DP, TRI1_DM, TRI1_DP	—	0.025	μA	1
I _{ILKG_A}	Input leakage current (per pin) for TRI0_DM, TRI0_DP, TRI1_DM, TRI1_DP	—	5	nA	1
I _{OZ}	Hi-Z (off-state) leakage current (per pin)	—	1	μA	
R _{PU}	Internal pullup resistors	20	50	kΩ	2
R _{PD}	Internal pulldown resistors	20	50	kΩ	3

1. Measured at VDD=3.6V
2. Measured at V_{DD} supply voltage = V_{DD} min and V_{input} = V_{SS}
3. Measured at V_{DD} supply voltage = V_{DD} min and V_{input} = V_{DD}

5.2.4 Power mode transition operating behaviors

All specifications except t_{POR}, and VLLS_x→RUN recovery times in the following table assume this clock configuration:

- CPU and system clocks = 72 MHz
- Bus clock = 36 MHz
- Flash clock = 24 MHz

Table 5. Power mode transition operating behaviors

Symbol	Description	Min.	Max.	Unit	Notes
t_{POR}	After a POR event, amount of time from the point V_{DD} reaches 1.71 V to execution of the first instruction across the operating temperature range of the chip.	—	300	μs	1
	• VLLS1 → RUN	—	112	μs	
	• VLLS2 → RUN	—	74	μs	
	• VLLS3 → RUN	—	73	μs	
	• LLS → RUN	—	5.9	μs	
	• VLPS → RUN	—	5.8	μs	
	• STOP → RUN	—	4.2	μs	

1. Normal boot (FTFL_OPT[LPBOOT]=1)

5.2.5 Power consumption operating behaviors

Table 6. Power consumption operating behaviors

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
I_{DDA}	Analog supply current	—	—	See note	mA	1
I_{DD_RUN}	Run mode current — all peripheral clocks disabled, code executing from flash					2
	• @ 1.8V	—	21.5	25	mA	
	• @ 3.0V	—	21.5	30	mA	
I_{DD_RUN}	Run mode current — all peripheral clocks enabled, code executing from flash					3, 4
	• @ 1.8V	—	31	34	mA	
	• @ 3.0V					
	• @ 25°C	—	31	34	mA	
	• @ 125°C	—	32	39	mA	
I_{DD_WAIT}	Wait mode high frequency current at 3.0 V — all peripheral clocks disabled	—	12.5	—	mA	2
I_{DD_WAIT}	Wait mode reduced frequency current at 3.0 V — all peripheral clocks disabled	—	7.2	—	mA	5
I_{DD_VLPR}	Very-low-power run mode current at 3.0 V — all peripheral clocks disabled	—	0.996	—	mA	6
I_{DD_VLPR}	Very-low-power run mode current at 3.0 V — all peripheral clocks enabled	—	1.46	—	mA	7

Table continues on the next page...

Table 6. Power consumption operating behaviors (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
I _{DD_VLPW}	Very-low-power wait mode current at 3.0 V — all peripheral clocks disabled	—	0.61	—	mA	8
I _{DD_STOP}	Stop mode current at 3.0 V					
	• @ -40 to 25°C	—	0.35	0.567	mA	
	• @ 70°C	—	0.384	0.793	mA	
	• @ 105°C	—	0.628	1.2	mA	
I _{DD_VLPS}	Very-low-power stop mode current at 3.0 V					
	• @ -40 to 25°C	—	5.9	32.7	μA	
	• @ 70°C	—	26.1	59.8	μA	
	• @ 105°C	—	98.1	188	μA	
I _{DD_LLS}	Low leakage stop mode current at 3.0 V					9
	• @ -40 to 25°C	—	2.6	8.6	μA	
	• @ 70°C	—	10.3	29.1	μA	
	• @ 105°C	—	42.5	92.5	μA	
I _{DD_VLLS3}	Very low-leakage stop mode 3 current at 3.0 V					9
	• @ -40 to 25°C	—	1.9	5.8	μA	
	• @ 70°C	—	6.9	12.1	μA	
	• @ 105°C	—	28.1	41.9	μA	
I _{DD_VLLS2}	Very low-leakage stop mode 2 current at 3.0 V					
	• @ -40 to 25°C	—	1.59	5.5	μA	
	• @ 70°C	—	4.3	9.5	μA	
	• @ 105°C	—	17.5	34	μA	
I _{DD_VLLS1}	Very low-leakage stop mode 1 current at 3.0 V					
	• @ -40 to 25°C	—	1.47	5.4	μA	
	• @ 70°C	—	2.97	8.1	μA	
	• @ 105°C	—	12.41	32	μA	
I _{DD_VBAT}	Average current with RTC and 32kHz disabled at 3.0 V					
	• @ -40 to 25°C	—	0.19	0.22	μA	
	• @ 70°C	—	0.49	0.64	μA	
	• @ 105°C	—	2.2	3.2	μA	

Table continues on the next page...

Table 6. Power consumption operating behaviors (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
I _{DD_VBAT}	Average current when CPU is not accessing RTC registers					10
	• @ 1.8V					
	• @ -40 to 25°C	—	0.57	0.67	μA	
	• @ 70°C	—	0.90	1.2	μA	
	• @ 105°C	—	2.4	3.5	μA	
	• @ 3.0V					
	• @ -40 to 25°C	—	0.67	0.94	μA	
	• @ 70°C	—	1.0	1.4	μA	
	• @ 105°C	—	2.7	3.9	μA	

1. The analog supply current is the sum of the active or disabled current for each of the analog modules on the device. See each module's specification for its supply current.
2. 72MHz core and system clock, 36MHz bus clock, and 24MHz flash clock. MCG configured for FEE mode. All peripheral clocks disabled.
3. 72MHz core and system clock, 36MHz bus clock, and 24MHz flash clock. MCG configured for FEE mode. All peripheral clocks enabled.
4. Max values are measured with CPU executing DSP instructions.
5. 25MHz core, system, bus and flash clock. MCG configured for FEI mode.
6. 4 MHz core and system clock, 4 MHz and bus clock, and 1 MHz flash clock. MCG configured for BLPE mode. All peripheral clocks disabled. Code executing from flash.
7. 4 MHz core and system clock, 4 MHz and bus clock, and 1 MHz flash clock. MCG configured for BLPE mode. All peripheral clocks enabled but peripherals are not in active operation. Code executing from flash.
8. 4 MHz core and system clock, 4 MHz and bus clock, and 1 MHz flash clock. MCG configured for BLPE mode. All peripheral clocks disabled.
9. Data reflects devices with 128 KB of RAM. For devices with 64 KB of RAM, power consumption is reduced by 2 μA.
10. Includes 32kHz oscillator current and RTC operation.

5.2.5.1 Diagram: Typical I_{DD_RUN} operating behavior

The following data was measured under these conditions:

- MCG in FBE mode for 50 MHz and lower frequencies. MCG in FEE mode at greater than 50 MHz frequencies.
- USB regulator disabled
- No GPIOs toggled
- Code execution from flash with cache enabled
- For the ALLOFF curve, all peripheral clocks are disabled except FTFL

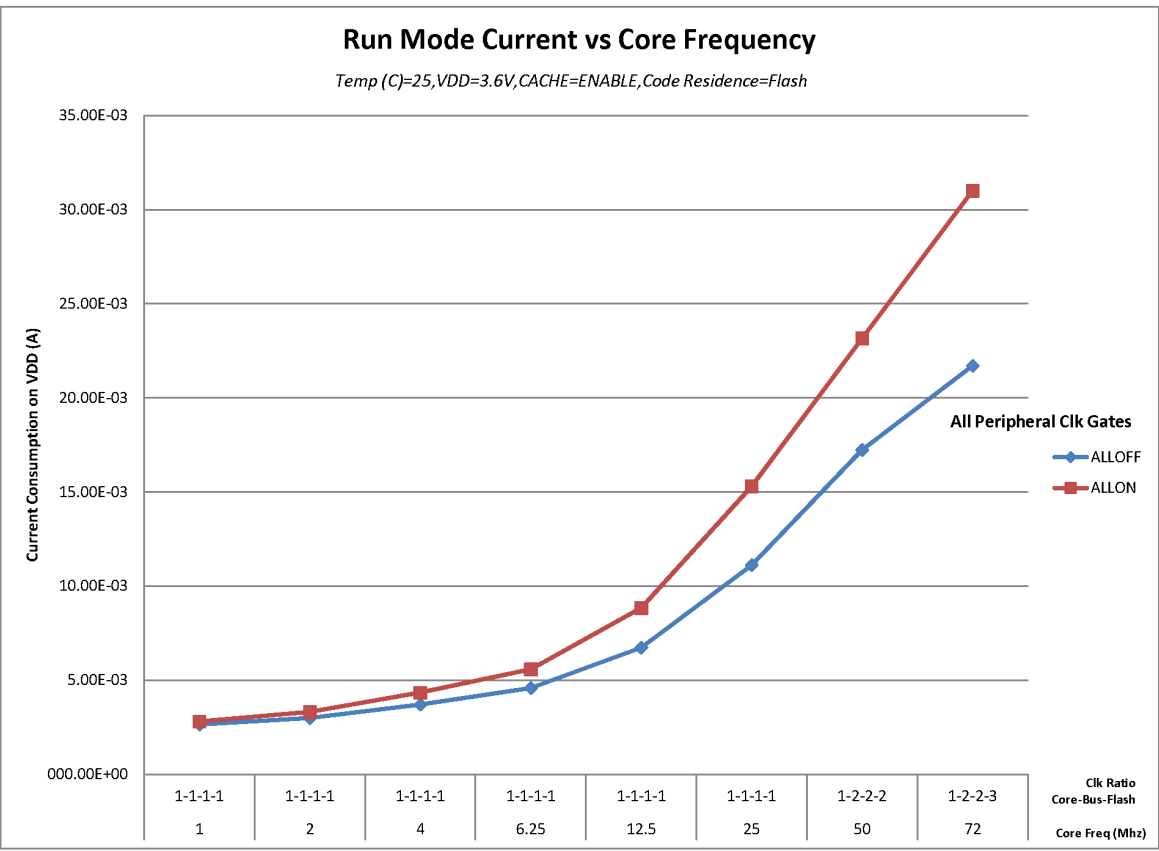


Figure 2. Run mode supply current vs. core frequency

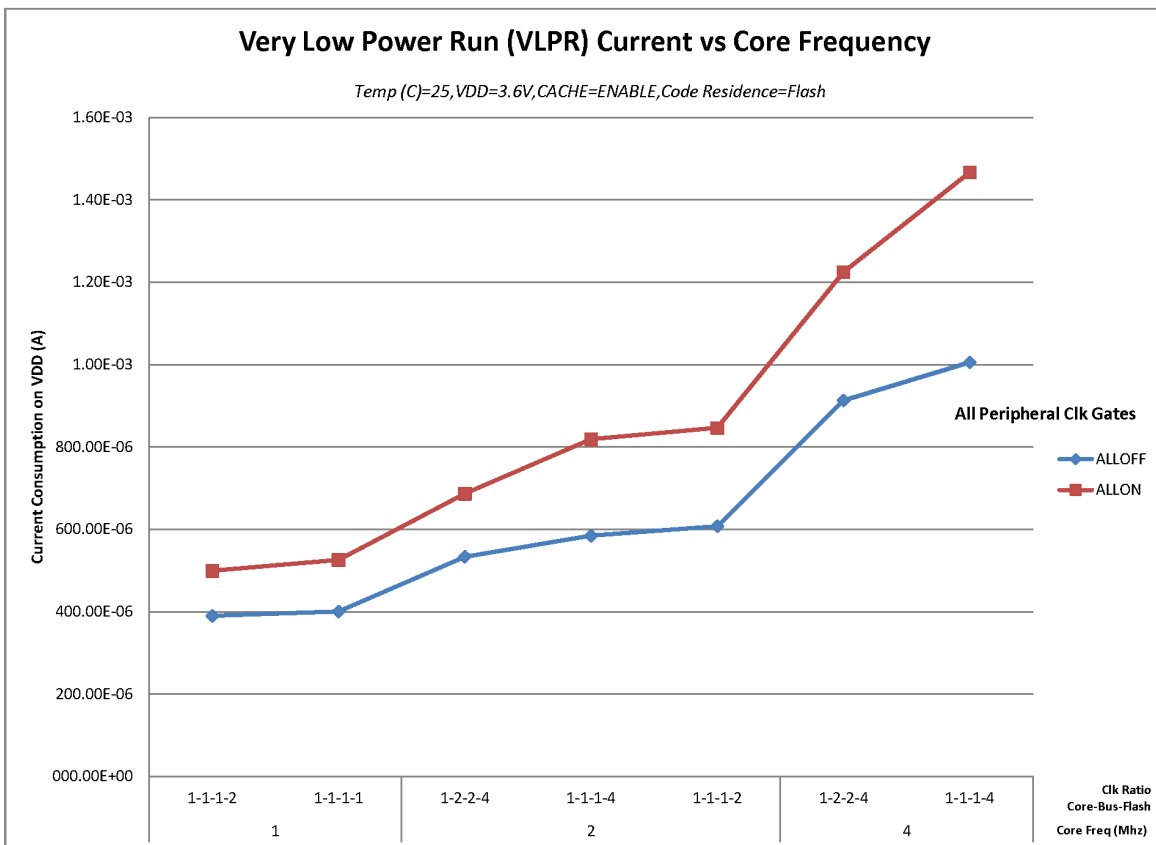


Figure 3. VLPR mode supply current vs. core frequency

5.2.6 Designing with radiated emissions in mind

To find application notes that provide guidance on designing your system to minimize interference from radiated emissions:

1. Go to www.freescale.com.
2. Perform a keyword search for “EMC design.”

5.2.7 Capacitance attributes

Table 7. Capacitance attributes

Symbol	Description	Min.	Max.	Unit
C _{IN_A}	Input capacitance: analog pins	—	7	pF
C _{IN_D}	Input capacitance: digital pins	—	7	pF

5.3 Switching specifications

5.3.1 Device clock specifications

Table 8. Device clock specifications

Symbol	Description	Min.	Max.	Unit	Notes
Normal run mode					
f _{SYS}	System and core clock	—	72	MHz	
f _{SYS_USB}	System and core clock when Full Speed USB in operation	20	—	MHz	
f _{BUS}	Bus clock	—	50	MHz	
f _{FLASH}	Flash clock	—	25	MHz	
f _{LPTMR}	LPTMR clock	—	25	MHz	
VLPR mode ¹					
f _{SYS}	System and core clock	—	4	MHz	
f _{BUS}	Bus clock	—	4	MHz	
f _{FLASH}	Flash clock	—	0.5	MHz	
f _{ERCLK}	External reference clock	—	16	MHz	
f _{LPTMR_pin}	LPTMR clock	—	25	MHz	
f _{LPTMR_ERCLK}	LPTMR external reference clock	—	16	MHz	
f _{FlexCAN_ERCLK}	FlexCAN external reference clock	—	8	MHz	
f _{I2S_MCLK}	I2S master clock	—	12.5	MHz	
f _{I2S_BCLK}	I2S bit clock	—	4	MHz	

1. The frequency limitations in VLPR mode here override any frequency specification listed in the timing specification for any other module.

5.3.2 General switching specifications

These general purpose specifications apply to all signals configured for GPIO, UART, CMT, and I²C signals.

Table 9. General switching specifications

Symbol	Description	Min.	Max.	Unit	Notes
	GPIO pin interrupt pulse width (digital glitch filter disabled) — Synchronous path	1.5	—	Bus clock cycles	1, 2
	GPIO pin interrupt pulse width (digital glitch filter disabled, analog filter enabled) — Asynchronous path	100	—	ns	3

Table continues on the next page...

Table 9. General switching specifications (continued)

Symbol	Description	Min.	Max.	Unit	Notes
	GPIO pin interrupt pulse width (digital glitch filter disabled, analog filter disabled) — Asynchronous path	16	—	ns	3
	External reset pulse width (digital glitch filter disabled)	100	—	ns	3
	Mode select (EZP_CS) hold time after reset deassertion	2	—	Bus clock cycles	
	Port rise and fall time (high drive strength) <ul style="list-style-type: none"> • Slew disabled <ul style="list-style-type: none"> • $1.71 \leq V_{DD} \leq 2.7V$ • $2.7 \leq V_{DD} \leq 3.6V$ • Slew enabled <ul style="list-style-type: none"> • $1.71 \leq V_{DD} \leq 2.7V$ • $2.7 \leq V_{DD} \leq 3.6V$ 	— — — —	12 6 36 24	ns ns ns ns	4
	Port rise and fall time (low drive strength) <ul style="list-style-type: none"> • Slew disabled <ul style="list-style-type: none"> • $1.71 \leq V_{DD} \leq 2.7V$ • $2.7 \leq V_{DD} \leq 3.6V$ • Slew enabled <ul style="list-style-type: none"> • $1.71 \leq V_{DD} \leq 2.7V$ • $2.7 \leq V_{DD} \leq 3.6V$ 	— — — —	12 6 36 24	ns ns ns ns	5

1. This is the minimum pulse width that is guaranteed to pass through the pin synchronization circuitry. Shorter pulses may or may not be recognized. In Stop, VLPS, LLS, and VLLSx modes, the synchronizer is bypassed so shorter pulses can be recognized in that case.
2. The greater synchronous and asynchronous timing must be met.
3. This is the minimum pulse width that is guaranteed to be recognized as a pin interrupt request in Stop, VLPS, LLS, and VLLSx modes.
4. 75pF load
5. 15pF load

5.4 Thermal specifications

5.4.1 Thermal operating requirements

Table 10. Thermal operating requirements

Symbol	Description	Min.	Max.	Unit
T_J	Die junction temperature	-40	125	°C
T_A	Ambient temperature	-40	85	°C

5.4.2 Thermal attributes

Board type	Symbol	Description	121 MAPBGA	100 LQFP	Unit	Notes
Single-layer (1s)	$R_{\theta JA}$	Thermal resistance, junction to ambient (natural convection)	74	52	°C/W	1, 2
Four-layer (2s2p)	$R_{\theta JA}$	Thermal resistance, junction to ambient (natural convection)	42	40	°C/W	1, 3
Single-layer (1s)	$R_{\theta JMA}$	Thermal resistance, junction to ambient (200 ft./min. air speed)	62	42	°C/W	1,3
Four-layer (2s2p)	$R_{\theta JMA}$	Thermal resistance, junction to ambient (200 ft./min. air speed)	38	34	°C/W	1,3
—	$R_{\theta JB}$	Thermal resistance, junction to board	23	25	°C/W	4
—	$R_{\theta JC}$	Thermal resistance, junction to case	19	12	°C/W	5
—	Ψ_{JT}	Thermal characterization parameter, junction to package top outside center (natural convection)	4	2	°C/W	6

1. 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.
2. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)* with the single layer board horizontal. For the LQFP, the board meets the JESD51-3 specification. For the MAPBGA, the board meets the JESD51-9 specification.
3. Determined according to JEDEC Standard JESD51-6, *Integrated Circuits Thermal Test Method Environmental Conditions—Forced Convection (Moving Air)* with the board horizontal. For the LQFP, the board meets the JESD51-7 specification.
4. Determined according to JEDEC Standard JESD51-8, *Integrated Circuit Thermal Test Method Environmental Conditions—Junction-to-Board*. Board temperature is measured on the top surface of the board near the package.

5. Determined according to Method 1012.1 of MIL-STD 883, *Test Method Standard, Microcircuits*, with the cold plate temperature used for the case temperature. The value includes the thermal resistance of the interface material between the top of the package and the cold plate.
6. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)*.

6 Peripheral operating requirements and behaviors

6.1 Core modules

6.1.1 Debug trace timing specifications

Table 11. Debug trace operating behaviors

Symbol	Description	Min.	Max.	Unit
T_{cyc}	Clock period	Frequency dependent		MHz
T_{wl}	Low pulse width	2	—	ns
T_{wh}	High pulse width	2	—	ns
T_r	Clock and data rise time	—	3	ns
T_f	Clock and data fall time	—	3	ns
T_s	Data setup	3	—	ns
T_h	Data hold	2	—	ns

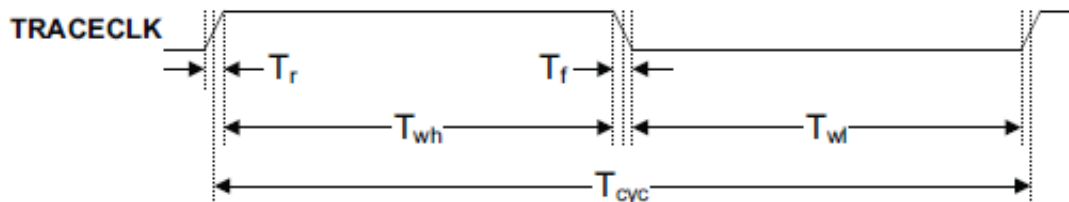


Figure 4. TRACE_CLKOUT specifications

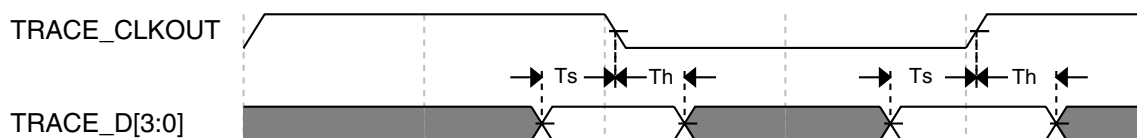


Figure 5. Trace data specifications

6.1.2 JTAG electricals

Table 12. JTAG limited voltage range electricals

Symbol	Description	Min.	Max.	Unit
	Operating voltage	2.7	3.6	V
J1	TCLK frequency of operation <ul style="list-style-type: none"> • Boundary Scan • JTAG and CJTAG • Serial Wire Debug 	0 0 0	10 25 50	MHz
J2	TCLK cycle period	1/J1	—	ns
J3	TCLK clock pulse width <ul style="list-style-type: none"> • Boundary Scan • JTAG and CJTAG • Serial Wire Debug 	50 20 10	— — —	ns ns ns
J4	TCLK rise and fall times	—	3	ns
J5	Boundary scan input data setup time to TCLK rise	20	—	ns
J6	Boundary scan input data hold time after TCLK rise	0	—	ns
J7	TCLK low to boundary scan output data valid	—	25	ns
J8	TCLK low to boundary scan output high-Z	—	25	ns
J9	TMS, TDI input data setup time to TCLK rise	8	—	ns
J10	TMS, TDI input data hold time after TCLK rise	1	—	ns
J11	TCLK low to TDO data valid	—	17	ns
J12	TCLK low to TDO high-Z	—	17	ns
J13	TRST assert time	100	—	ns
J14	TRST setup time (negation) to TCLK high	8	—	ns

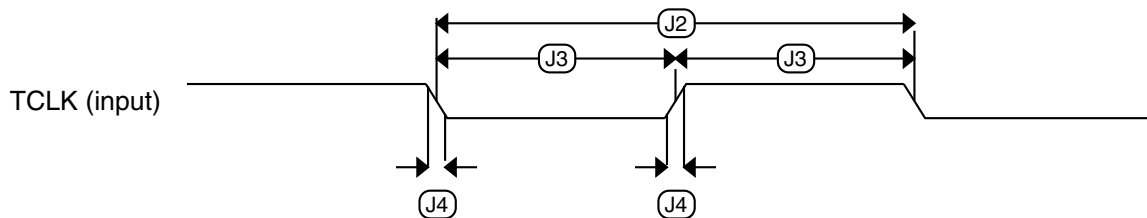
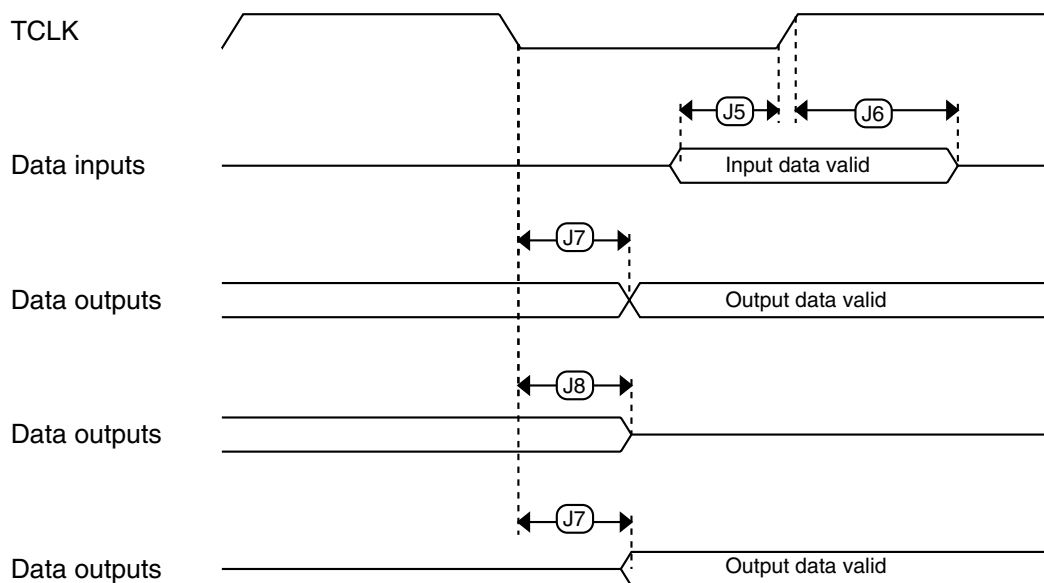
Table 13. JTAG full voltage range electricals

Symbol	Description	Min.	Max.	Unit
	Operating voltage	1.71	3.6	V
J1	TCLK frequency of operation <ul style="list-style-type: none"> • Boundary Scan • JTAG and CJTAG • Serial Wire Debug 	0 0 0	10 20 40	MHz
J2	TCLK cycle period	1/J1	—	ns
J3	TCLK clock pulse width <ul style="list-style-type: none"> • Boundary Scan • JTAG and CJTAG • Serial Wire Debug 	50 25 12.5	— — —	ns ns ns
J4	TCLK rise and fall times	—	3	ns

Table continues on the next page...

Table 13. JTAG full voltage range electricals (continued)

Symbol	Description	Min.	Max.	Unit
J5	Boundary scan input data setup time to TCLK rise	20	—	ns
J6	Boundary scan input data hold time after TCLK rise	0	—	ns
J7	TCLK low to boundary scan output data valid	—	25	ns
J8	TCLK low to boundary scan output high-Z	—	25	ns
J9	TMS, TDI input data setup time to TCLK rise	8	—	ns
J10	TMS, TDI input data hold time after TCLK rise	1.4	—	ns
J11	TCLK low to TDO data valid	—	22.1	ns
J12	TCLK low to TDO high-Z	—	22.1	ns
J13	TRST assert time	100	—	ns
J14	TRST setup time (negation) to TCLK high	8	—	ns


Figure 6. Test clock input timing

Figure 7. Boundary scan (JTAG) timing