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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	e200z0h
Core Size	32-Bit Single-Core
Speed	64MHz
Connectivity	CANbus, FlexRay, LINbus, SPI, UART/USART
Peripherals	DMA, POR, PWM, WDT
Number of I/O	68
Program Memory Size	384KB (384K x 8)
Program Memory Type	FLASH
EEPROM Size	64K x 8
RAM Size	36K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 5.5V
Data Converters	A/D 30x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	100-LQFP
Supplier Device Package	100-LQFP (14x14)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/spc5603pef1mll6r

1 Introduction

1.1 Document overview

This document provides electrical specifications, pin assignments, and package diagrams for the MPC5603P/4P series of microcontroller units (MCUs). It also describes the device features and highlights important electrical and physical characteristics. For functional characteristics, refer to the device reference manual.

1.2 Description

This 32-bit system-on-chip (SoC) automotive microcontroller family is the latest achievement in integrated automotive application controllers. It belongs to an expanding range of automotive-focused products designed to address chassis applications—specifically, electrical hydraulic power steering (EHPS) and electric power steering (EPS)—as well as airbag applications.

This family is one of a series of next-generation integrated automotive microcontrollers based on the Power Architecture technology.

The advanced and cost-efficient host processor core of this automotive controller family complies with the Power Architecture embedded category. It operates at speeds of up to 64 MHz and offers high performance processing optimized for low power consumption. It capitalizes on the available development infrastructure of current Power Architecture devices and is supported with software drivers, operating systems and configuration code to assist with users implementations.

1.3 Device comparison

Table 1 provides a summary of different members of the MPC5604P family and their features to enable a comparison among the family members and an understanding of the range of functionality offered within this family.

Table 1. MPC5604P device comparison

Feature	MPC5603P	MPC5604P
Code flash memory (with ECC)	384 KB	512 KB
Data flash memory / EE option (with ECC)	64 KB (optional feature)	
SRAM (with ECC)	36 KB	40 KB
Processor core	32-bit e200z0h	
Instruction set	VLE (variable length encoding)	
CPU performance	0–64 MHz	
FMPLL (frequency-modulated phase-locked loop) module	2	
INTC (interrupt controller) channels	147	
PIT (periodic interrupt timer)	1 (includes four 32-bit timers)	
eDMA (enhanced direct memory access) channels	16	
FlexRay[1]	Optional feature	
FlexCAN (controller area network)	2[2,3]	
Safety port	Yes (via second FlexCAN module)	
FCU (fault collection unit)	Yes	
CTU (cross triggering unit)	Yes	

For high priority interrupt requests, the time from the assertion of the interrupt request from the peripheral to when the processor is executing the interrupt service routine (ISR) has been minimized. The INTC provides a unique vector for each interrupt request source for quick determination of which ISR has to be executed. It also provides a wide number of priorities so that lower priority ISRs do not delay the execution of higher priority ISRs. To allow the appropriate priorities for each source of interrupt request, the priority of each interrupt request is software configurable.

When multiple tasks share a resource, coherent accesses to that resource need to be supported. The INTC supports the priority ceiling protocol (PCP) for coherent accesses. By providing a modifiable priority mask, the priority can be raised temporarily so that all tasks which share the same resource can not preempt each other.

The INTC provides the following features:

- Unique 9-bit vector for each separate interrupt source
- 8 software triggerable interrupt sources
- 16 priority levels with fixed hardware arbitration within priority levels for each interrupt source
- Ability to modify the ISR or task priority: modifying the priority can be used to implement the Priority Ceiling Protocol for accessing shared resources.
- 2 external high priority interrupts directly accessing the main core and I/O processor (IOP) critical interrupt mechanism

1.5.7 System status and configuration module (SSCM)

The system status and configuration module (SSCM) provides central device functionality.

The SSCM includes these features:

- System configuration and status
  - Memory sizes/status
  - Device mode and security status
  - Determine boot vector
  - Search code flash for bootable sector
  - DMA status
- Debug status port enable and selection
- Bus and peripheral abort enable/disable

1.5.8 System clocks and clock generation

The following list summarizes the system clock and clock generation on the MPC5604P:

- Lock detect circuitry continuously monitors lock status
- Loss of clock (LOC) detection for PLL outputs
- Programmable output clock divider (÷1, ÷2, ÷4, ÷8)
- FlexPWM module and eTimer module can run on an independent clock source
- On-chip oscillator with automatic level control
- Internal 16 MHz RC oscillator for rapid start-up and safe mode: supports frequency trimming by user application

1.5.9 Frequency-modulated phase-locked loop (FMPLL)

The FMPLL allows the user to generate high speed system clocks from a 4–40 MHz input clock. Further, the FMPLL supports programmable frequency modulation of the system clock. The PLL multiplication factor, output clock divider ratio are all software configurable.

The PLL has the following major features:

- Input clock frequency: 4–40 MHz

- 32-bit time-out register to set the time-out period
- Programmable selection of system or oscillator clock for timer operation
- Programmable selection of window mode or regular servicing
- Programmable selection of reset or interrupt on an initial time-out
- Master access protection
- Hard and soft configuration lock bits
- Reset configuration inputs allow timer to be enabled out of reset

1.5.15 Fault collection unit (FCU)

The FCU provides an independent fault reporting mechanism even if the CPU is malfunctioning.

The FCU module has the following features:

- FCU status register reporting the device status
- Continuous monitoring of critical fault signals
- User selection of critical signals from different fault sources inside the device
- Critical fault events trigger 2 external pins (user selected signal protocol) that can be used externally to reset the device and/or other circuitry (for example, safety relay or FlexRay transceiver)
- Faults are latched into a register

1.5.16 System integration unit – Lite (SIUL)

The MPC5604P SIUL controls MCU pad configuration, external interrupt, general purpose I/O (GPIO), and internal peripheral multiplexing.

The pad configuration block controls the static electrical characteristics of I/O pins. The GPIO block provides uniform and discrete input/output control of the I/O pins of the MCU.

The SIU provides the following features:

- Centralized general purpose input output (GPIO) control of as many as 80 input/output pins and 26 analog input-only pads (package dependent)
- All GPIO pins can be independently configured to support pull-up, pull down, or no pull
- Reading and writing to GPIO supported both as individual pins and 16-bit wide ports
- All peripheral pins (except ADC channels) can be alternatively configured as both general purpose input or output pins
- ADC channels support alternative configuration as general purpose inputs
- Direct readback of the pin value is supported on all pins through the SIUL
- Configurable digital input filter that can be applied to some general purpose input pins for noise elimination: as many as 4 internal functions can be multiplexed onto 1 pin

1.5.17 Boot and censorship

Different booting modes are available in the MPC5604P: booting from internal flash memory and booting via a serial link.

The default booting scheme uses the internal flash memory (an internal pull-down is used to select this mode). Optionally, the user can boot via FlexCAN or LINFlex (using the boot assist module software).

A censorship scheme is provided to protect the content of the flash memory and offer increased security for the entire device.

A password mechanism is designed to grant the legitimate user access to the non-volatile memory.

1.5.17.1 Boot assist module (BAM)

The BAM is a block of read-only one-time programmed memory and is identical for all MPC560xP devices that are based on the e200z0h core. The BAM program is executed every time the device is powered on if the alternate boot mode has been selected by the user.

The BAM provides the following features:

- Serial bootloading via FlexCAN or LINFlex
- Ability to accept a password via the used serial communication channel to grant the legitimate user access to the non-volatile memory

1.5.18 Error correction status module (ECSM)

The ECSM provides a myriad of miscellaneous control functions regarding program-visible information about the platform configuration and revision levels, a reset status register, a software watchdog timer, wakeup control for exiting sleep modes, and information on platform memory errors reported by error-correcting codes and/or generic access error information for certain processor cores.

The Error Correction Status Module supports a number of miscellaneous control functions for the platform. The ECSM includes these features:

- Registers for capturing information on platform memory errors if error-correcting codes (ECC) are implemented
- For test purposes, optional registers to specify the generation of double-bit memory errors are enabled on the MPC5604P.

The sources of the ECC errors are:

- Flash memory
- SRAM

1.5.19 Peripheral bridge (PBRIDGE)

The PBRIDGE implements the following features:

- Duplicated periphery
- Master access privilege level per peripheral (per master: read access enable; write access enable)
- Write buffering for peripherals
- Checker applied on PBRIDGE output toward periphery
- Byte endianess swap capability

1.5.20 Controller area network (FlexCAN)

The MPC5604P MCU contains one controller area network (FlexCAN) module. This module is a communication controller implementing the CAN protocol according to Bosch Specification version 2.0B. The CAN protocol was designed to be used primarily as a vehicle serial data bus, meeting the specific requirements of this field: real-time processing, reliable operation in the EMI environment of a vehicle, cost-effectiveness and required bandwidth. The FlexCAN module contains 32 message buffers.

The FlexCAN module provides the following features:

- Full implementation of the CAN protocol specification, version 2.0B
  - Standard data and remote frames
  - Extended data and remote frames
  - Up to 8-bytes data length
  - Programmable bit rate up to 1 Mbit/s

— Watchpoint triggering, watchpoint triggers program tracing
- Auxiliary Output Port
  — 4 MDO (Message Data Out) pins
  — MCKO (Message Clock Out) pin
  — 2 $\overline{\text{MSEO}}$ (Message Start/End Out) pins
  — $\overline{\text{EVTO}}$ (Event Out) pin
- Auxiliary Input Port
  — $\overline{\text{EVTI}}$ (Event In) pin

1.5.30 Cyclic redundancy check (CRC)

The CRC computing unit is dedicated to the computation of CRC off-loading the CPU. The CRC module features:

- Support for CRC-16-CCITT ($x25$ protocol):
  — $x^{16} + x^{12} + x^5 + 1$
- Support for CRC-32 (Ethernet protocol):
  — $x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$
- Zero wait states for each write/read operations to the CRC_CFG and CRC_INP registers at the maximum frequency

1.5.31 IEEE 1149.1 JTAG controller

The JTAG controller (JTAGC) block provides the means to test chip functionality and connectivity while remaining transparent to system logic when not in test mode. All data input to and output from the JTAGC block is communicated in serial format. The JTAGC block is compliant with the IEEE standard.

The JTAG controller provides the following features:

- IEEE Test Access Port (TAP) interface with 4 pins (TDI, TMS, TCK, TDO)
- Selectable modes of operation include JTAGC/debug or normal system operation.
- A 5-bit instruction register that supports the following IEEE 1149.1-2001 defined instructions:
  — BYPASS, IDCODE, EXTEST, SAMPLE, SAMPLE/PRELOAD
- A 5-bit instruction register that supports the additional following public instructions:
  — ACCESS_AUX_TAP_NPC, ACCESS_AUX_TAP_ONCE
- 3 test data registers: a bypass register, a boundary scan register, and a device identification register.
- A TAP controller state machine that controls the operation of the data registers, instruction register and associated circuitry.

1.5.32 On-chip voltage regulator (VREG)

The on-chip voltage regulator module provides the following features:

- Uses external NPN (negative-positive-negative) transistor
- Regulates external 3.3 V /5.0 V down to 1.2 V for the core logic
- Low voltage detection on the internal 1.2 V and I/O voltage 3.3 V

Table 5. Pin muxing (continued)

Port pin	Pad configuration register (PCR)	Alternate function[1,2]	Functions	Peripheral[3]	I/O direction[4]	Pad speed[5]		Pin No.	
						SRC = 0	SRC = 1	100-pin	144-pin
B[10]	PCR[26]	ALT0 ALT1 ALT2 ALT3 —	GPIO[26] — — — AN[12]	SIUL — — — ADC_0 / ADC_1	Input only	—	—	36	53
B[11]	PCR[27]	ALT0 ALT1 ALT2 ALT3 —	GPIO[27] — — — AN[13]	SIUL — — — ADC_0 / ADC_1	Input only	—	—	37	54
B[12]	PCR[28]	ALT0 ALT1 ALT2 ALT3 —	GPIO[28] — — — AN[14]	SIUL — — — ADC_0 / ADC_1	Input only	—	—	38	55
B[13]	PCR[29]	ALT0 ALT1 ALT2 ALT3 — —	GPIO[29] — — — AN[0] RXD	SIUL — — — ADC_1 LIN_1	Input only	—	—	42	60
B[14]	PCR[30]	ALT0 ALT1 ALT2 ALT3 — — —	GPIO[30] — — — AN[1] ETC[4] EIRQ[19]	SIUL — — — ADC_1 eTimer_0 SIUL	Input only	—	—	44	64
B[15]	PCR[31]	ALT0 ALT1 ALT2 ALT3 — —	GPIO[31] — — — AN[2] EIRQ[20]	SIUL — — — ADC_1 SIUL	Input only	—	—	43	62
Port C (16-bit)									
C[0]	PCR[32]	ALT0 ALT1 ALT2 ALT3 —	GPIO[32] — — — AN[3]	SIUL — — — ADC_1	Input only	—	—	45	66
C[1]	PCR[33]	ALT0 ALT1 ALT2 ALT3 —	GPIO[33] — — — AN[2]	SIUL — — — ADC_0	Input only	—	—	28	41

Table 5. Pin muxing (continued)

Port pin	Pad configuration register (PCR)	Alternate function[1,2]	Functions	Peripheral[3]	I/O direction[4]	Pad speed[5]		Pin No.	
						SRC = 0	SRC = 1	100-pin	144-pin
C[2]	PCR[34]	ALT0 ALT1 ALT2 ALT3 —	GPIO[34] — — — AN[3]	SIUL — — — ADC_0	Input only	—	—	30	45
C[3]	PCR[35]	ALT0 ALT1 ALT2 ALT3 —	GPIO[35] CS1 ETC[4] TXD EIRQ[21]	SIUL DSPI_0 eTimer_1 LIN_1 SIUL	I/O O I/O O I	Slow	Medium	10	16
C[4]	PCR[36]	ALT0 ALT1 ALT2 ALT3 —	GPIO[36] CS0 X[1] DEBUG[4] EIRQ[22]	SIUL DSPI_0 FlexPWM_0 SSCM SIUL	I/O I/O I/O — I	Slow	Medium	5	11
C[5]	PCR[37]	ALT0 ALT1 ALT2 ALT3 — —	GPIO[37] SCK — DEBUG[5] FAULT[3] EIRQ[23]	SIUL DSPI_0 — SSCM FlexPWM_0 SIUL	I/O I/O — — I I	Slow	Medium	7	13
C[6]	PCR[38]	ALT0 ALT1 ALT2 ALT3 —	GPIO[38] SOUT B[1] DEBUG[6] EIRQ[24]	SIUL DSPI_0 FlexPWM_0 SSCM SIUL	I/O I/O O — I	Slow	Medium	98	142
C[7]	PCR[39]	ALT0 ALT1 ALT2 ALT3 —	GPIO[39] — A[1] DEBUG[7] SIN	SIUL — FlexPWM_0 SSCM DSPI_0	I/O — O — I	Slow	Medium	9	15
C[8]	PCR[40]	ALT0 ALT1 ALT2 ALT3 —	GPIO[40] CS1 — CS6 FAULT[2]	SIUL DSPI_1 — DSPI_0 FlexPWM_0	I/O O — O I	Slow	Medium	91	130
C[9]	PCR[41]	ALT0 ALT1 ALT2 ALT3 —	GPIO[41] CS3 — X[3] FAULT[2]	SIUL DSPI_2 — FlexPWM_0 FlexPWM_0	I/O O — I/O I	Slow	Medium	84	123
C[10]	PCR[42]	ALT0 ALT1 ALT2 ALT3 —	GPIO[42] CS2 — A[3] FAULT[1]	SIUL DSPI_2 — FlexPWM_0 FlexPWM_0	I/O O — O I	Slow	Medium	78	111

Table 5. Pin muxing (continued)

Port pin	Pad configuration register (PCR)	Alternate function[1,2]	Functions	Peripheral[3]	I/O direction[4]	Pad speed[5]		Pin No.	
						SRC = 0	SRC = 1	100-pin	144-pin
E[6]	PCR[70]	ALT0 ALT1 ALT2 ALT3 —	GPIO[70] — — — AN[9]	SIUL — — — ADC_0	Input only	—	—	—	46
E[7]	PCR[71]	ALT0 ALT1 ALT2 ALT3 —	GPIO[71] — — — AN[10]	SIUL — — — ADC_0	Input only	—	—	—	48
E[8]	PCR[72]	ALT0 ALT1 ALT2 ALT3 —	GPIO[72] — — — AN[6]	SIUL — — — ADC_1	Input only	—	—	—	59
E[9]	PCR[73]	ALT0 ALT1 ALT2 ALT3 —	GPIO[73] — — — AN[7]	SIUL — — — ADC_1	Input only	—	—	—	61
E[10]	PCR[74]	ALT0 ALT1 ALT2 ALT3 —	GPIO[74] — — — AN[8]	SIUL — — — ADC_1	Input only	—	—	—	63
E[11]	PCR[75]	ALT0 ALT1 ALT2 ALT3 —	GPIO[75] — — — AN[9]	SIUL — — — ADC_1	Input only	—	—	—	65
E[12]	PCR[76]	ALT0 ALT1 ALT2 ALT3 —	GPIO[76] — — — AN[10]	SIUL — — — ADC_1	Input only	—	—	—	67
E[13]	PCR[77]	ALT0 ALT1 ALT2 ALT3 —	GPIO[77] SCK — — EIRQ[25]	SIUL DSPI_3 — — SIUL	I/O I/O — — I	Slow	Medium	—	117
E[14]	PCR[78]	ALT0 ALT1 ALT2 ALT3 —	GPIO[78] SOUT — — EIRQ[26]	SIUL DSPI_3 — — SIUL	I/O O — — I	Slow	Medium	—	119

Table 7. Absolute maximum ratings[1] (continued)

Symbol		Parameter	Conditions	Value		Unit
				Min	Max[2]	
V_{INAN0}	SR	ADC0 and shared ADC0/1 analog input voltage[6]	$V_{DD\_HV\_REG}$ > 2.7 V	$V_{SS\_HV\_ADV0}$ – 0.3	$V_{DD\_HV\_ADV0}$ + 0.3	V
			$V_{DD\_HV\_REG}$ < 2.7 V	$V_{SS\_HV\_ADV0}$	$V_{DD\_HV\_ADV0}$	V
V_{INAN1}	SR	ADC1 analog input voltage[7]	$V_{DD\_HV\_REG}$ > 2.7 V	$V_{SS\_HV\_ADV1}$ – 0.3	$V_{DD\_HV\_ADV1}$ + 0.3	V
			$V_{DD\_HV\_REG}$ < 2.7 V	$V_{SS\_HV\_ADV1}$	$V_{DD\_HV\_ADV1}$	V
I_{INJPAD}	SR	Injected input current on any pin during overload condition	—	–10	10	mA
I_{INJSUM}	SR	Absolute sum of all injected input currents during overload condition	—	–50	50	mA
I_{VDD_LV}	SR	Low voltage static current sink through V_{DD_LV}	—	—	155	mA
T_{STG}	SR	Storage temperature	—	–55	150	°C
T_J	SR	Junction temperature under bias	—	–40	150	°C

1 Functional operating conditions are given in the DC electrical characteristics. 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 Absolute maximum voltages are currently maximum burn-in voltages. Absolute maximum specifications for device stress have not yet been determined.

3 The difference between each couple of voltage supplies must be less than 300 mV, $|V_{DD\_HV\_IOy} - V_{DD\_HV\_IOx}| < 300$ mV.

4 The difference between ADC voltage supplies must be less than 100 mV, $|V_{DD\_HV\_ADC1} - V_{DD\_HV\_ADC0}| < 100$ mV.

5 Guaranteed by device validation

6 Not allowed to refer this voltage to $V_{DD\_HV\_ADV1}$, $V_{SS\_HV\_ADV1}$

7 Not allowed to refer this voltage to $V_{DD\_HV\_ADV0}$, $V_{SS\_HV\_ADV0}$

Figure 4 shows the constraints of the different power supplies.

Table 17. Low voltage monitor electrical characteristics (continued)

Symbol	C	Parameter	Conditions[1]	Value		Unit
				Min	Max	
$V_{IOLVDM5OK\_H}$	P	I/O 5V low voltage detector high threshold	—	—	4.4	V
$V_{IOLVDM5OK\_L}$	P	I/O 5V low voltage detector low threshold	—	3.8	—	V
$V_{MLVDDOK\_H}$	P	Digital supply low voltage detector high	—	—	1.145	V
$V_{MLVDDOK\_L}$	P	Digital supply low voltage detector low	—	1.08	—	V

[1] V_{DD} = 3.3V ± 10% / 5.0V ± 10%, T_A = –40 °C to $T_{A\ MAX}$, unless otherwise specified

3.9 Power up/down sequencing

To prevent an overstress event or a malfunction within and outside the device, the MPC5604P implements the following sequence to ensure each module is started only when all conditions for switching it ON are available:

- A POWER_ON module working on voltage regulator supply controls the correct start-up of the regulator. This is a key module ensuring safe configuration for all voltage regulator functionality when supply is below 1.5V. Associated POWER_ON (or POR) signal is active low.
- Several low voltage detectors, working on voltage regulator supply monitor the voltage of the critical modules (voltage regulator, I/Os, flash memory and low voltage domain). LVDs are gated low when POWER_ON is active.
- A POWER_OK signal is generated when all critical supplies monitored by the LVD are available. This signal is active high and released to all modules including I/Os, flash memory and RC16 oscillator needed during power-up phase and reset phase. When POWER_OK is low the associated module are set into a safe state.

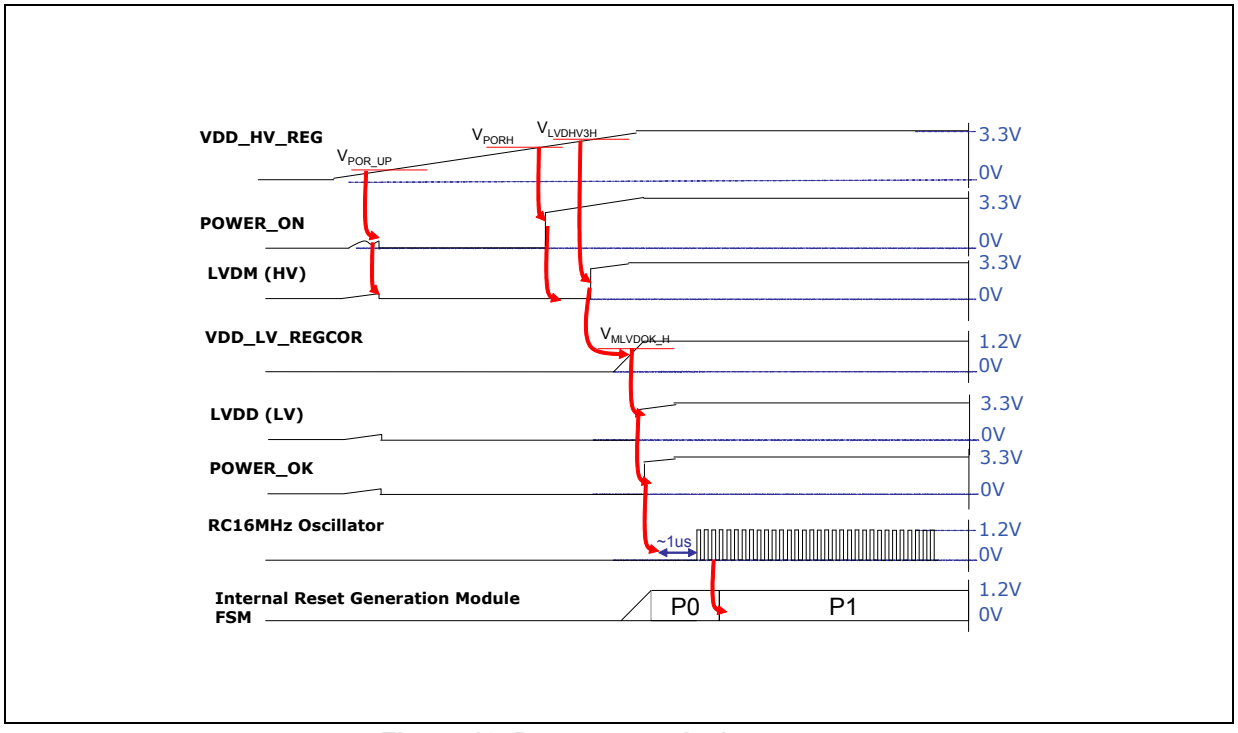

Figure 10. Power-up typical sequence

[3] Code fetched from RAM, PLL_0: 64 MHz system clock (x4 multiplier with 16 MHz XTAL), PLL_1 is ON at PHI_div2 = 120 MHz and PHI_div3 = 80 MHz, auxiliary clock sources set that all peripherals receive maximum frequency, all peripherals enabled.

[4] Halt mode configurations: code fetched from RAM, code and data flash memories in low power mode, OSC/PLL_0/PLL_1 are OFF, core clock frozen, all peripherals are disabled.

[5] STOP “P” mode Device Under Test (DUT) configuration: code fetched from RAM, code and data flash memories OFF, OSC/PLL_0/PLL_1 are OFF, core clock frozen, all peripherals are disabled.

3.10.3 DC electrical characteristics (3.3 V)

Table 21 gives the DC electrical characteristics at 3.3 V ($3.0\ V < V_{DD\_HV\_IOx} < 3.6\ V$, NVUSRO[PAD3V5V] = 1); see Figure 13.

Table 21. DC electrical characteristics (3.3 V, NVUSRO[PAD3V5V] = 1)[1]

Symbol	C	Parameter	Conditions	Value		Unit
				Min	Max	
V_{IL}	D	Low level input voltage	—	–0.1[2]	—	V
	P		—	—	0.35 $V_{DD\_HV\_IOx}$	V
V_{IH}	P	High level input voltage	—	0.65 $V_{DD\_HV\_IOx}$	—	V
	D		—	—	$V_{DD\_HV\_IOx}$ + 0.1[2]	V
V_{HYS}	T	Schmitt trigger hysteresis	—	0.1 $V_{DD\_HV\_IOx}$	—	V
V_{OL_S}	P	Slow, low level output voltage	I_{OL} = 1.5 mA	—	0.5	V
V_{OH_S}	P	Slow, high level output voltage	I_{OH} = –1.5 mA	$V_{DD\_HV\_IOx}$ – 0.8	—	V
V_{OL_M}	P	Medium, low level output voltage	I_{OL} = 2 mA	—	0.5	V
V_{OH_M}	P	Medium, high level output voltage	I_{OH} = –2 mA	$V_{DD\_HV\_IOx}$ – 0.8	—	V
V_{OL_F}	P	Fast, low level output voltage	I_{OL} = 1.5 mA	—	0.5	V
V_{OH_F}	P	Fast, high level output voltage	I_{OH} = –1.5 mA	$V_{DD\_HV\_IOx}$ – 0.8	—	V
V_{OL_SYM}	P	Symmetric, low level output voltage	I_{OL} = 1.5 mA	—	0.5	V
V_{OH_SYM}	P	Symmetric, high level output voltage	I_{OH} = –1.5 mA	$V_{DD\_HV\_IOx}$ – 0.8	—	V
I_{PU}	P	Equivalent pull-up current	$V_{IN} = V_{IL}$	–130	—	µA
			$V_{IN} = V_{IH}$	—	–10	
I_{PD}	P	Equivalent pull-down current	$V_{IN} = V_{IL}$	10	—	µA
			$V_{IN} = V_{IH}$	—	130	
I_{IL}	P	Input leakage current (all bidirectional ports)	T_A = –40 to 125 °C	—	1	µA
I_{IL}	P	Input leakage current (all ADC input-only ports)	T_A = –40 to 125 °C	—	0.5	µA
C_{IN}	D	Input capacitance	—	—	10	pF
I_{PU}	D	$\overline{\text{RESET}}$, equivalent pull-up current	$V_{IN} = V_{IL}$	–130	—	µA
			$V_{IN} = V_{IH}$	—	–10	

[1] These specifications are design targets and subject to change per device characterization.

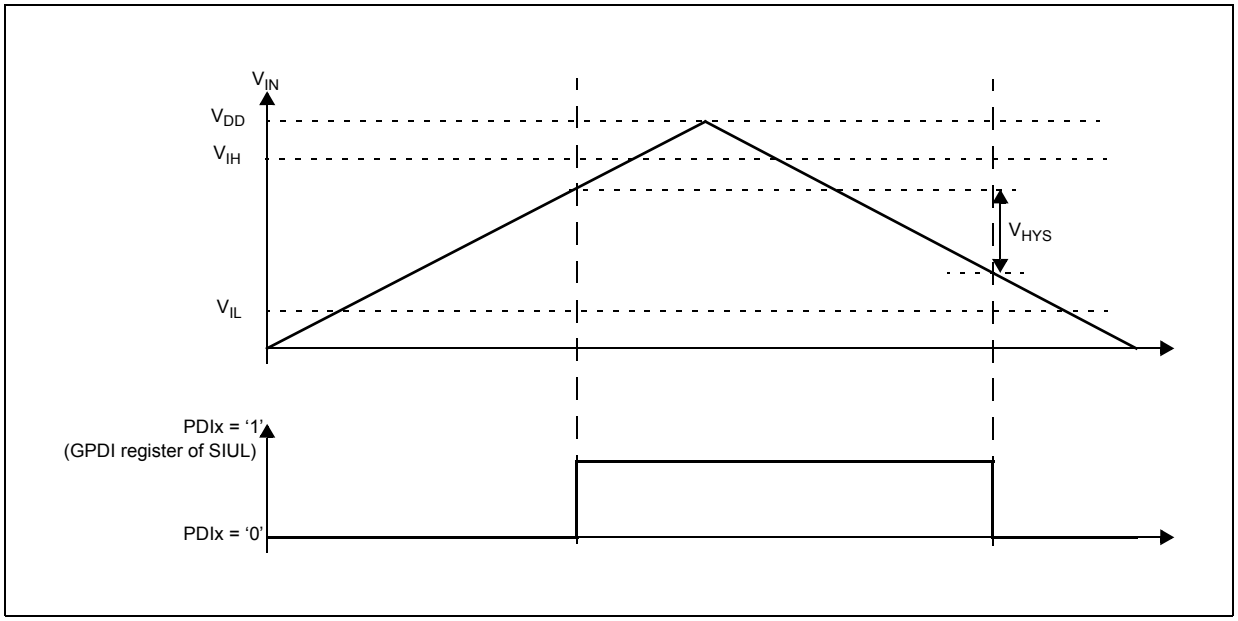

Figure 13. Input DC electrical characteristics definition

3.10.5 I/O pad current specification

The I/O pads are distributed across the I/O supply segment. Each I/O supply segment is associated to a V_{DD}/V_{SS} supply pair as described in Table 23.

Table 23. I/O supply segment

Package	Supply segment						
	1	2	3	4	5	6	7
144 LQFP	pin8 – pin20	pin23 – pin38	pin39 – pin55	pin58 – pin68	pin73 – pin89	pin92 – pin125	pin128 – pin5
100 LQFP	pin15 – pin26	pin27 – pin38	pin41 – pin46	pin51 – pin61	pin64 – pin86	pin89 – pin10	—

Table 24 provides the weight of concurrent switching I/Os.

In order to ensure device functionality, the sum of the weight of concurrent switching I/Os on a single segment should remain below 100%.

Table 24. I/O weight

Pad	144 LQFP		100 LQFP	
	Weight 5V	Weight 3.3V	Weight 5V	Weight 3.3V
NMI	1%	1%	1%	1%
PAD[6]	6%	5%	14%	13%
PAD[49]	5%	4%	14%	12%
PAD[84]	14%	10%	—	—
PAD[85]	9%	7%	—	—

Table 24. I/O weight (continued)

Pad	144 LQFP		100 LQFP	
	Weight 5V	Weight 3.3V	Weight 5V	Weight 3.3V
PAD[27]	1%	1%	1%	1%
PAD[28]	1%	1%	1%	1%
PAD[63]	1%	1%	1%	1%
PAD[72]	1%	1%	—	—
PAD[29]	1%	1%	1%	1%
PAD[73]	1%	1%	—	—
PAD[31]	1%	1%	1%	1%
PAD[74]	1%	1%	—	—
PAD[30]	1%	1%	1%	1%
PAD[75]	1%	1%	—	—
PAD[32]	1%	1%	1%	1%
PAD[76]	1%	1%	—	—
PAD[64]	1%	1%	1%	1%
PAD[0]	23%	20%	23%	20%
PAD[1]	21%	18%	21%	18%
PAD[107]	20%	17%	—	—
PAD[58]	19%	16%	19%	16%
PAD[106]	18%	16%	—	—
PAD[59]	17%	15%	17%	15%
PAD[105]	16%	14%	—	—
PAD[43]	15%	13%	15%	13%
PAD[104]	14%	13%	—	—
PAD[44]	13%	12%	13%	12%
PAD[103]	12%	11%	—	—
PAD[2]	11%	10%	11%	10%
PAD[101]	11%	9%	—	—
PAD[21]	10%	8%	10%	8%
TMS	1%	1%	1%	1%
TCK	1%	1%	1%	1%
PAD[20]	16%	11%	16%	11%
PAD[3]	4%	3%	4%	3%
PAD[61]	9%	8%	9%	8%
PAD[102]	11%	10%	—	—

Eqn. 11

$$\frac{V_A}{V_{A2}} = \frac{C_{P1} + C_{P2} + C_F}{C_{P1} + C_{P2} + C_F + C_S}$$

From this formula, in the worst case (when V_A is maximum, that is for instance 5 V), assuming to accept a maximum error of half a count, a constraint is evident on C_F value:

Eqn. 12

$$C_F > 2048 \bullet C_S$$

3.14.2 ADC conversion characteristics

Table 31. ADC conversion characteristics

Symbol		C	Parameter	Conditions[1]	Value			Unit
					Min	Typ	Max	
V_{INAN0}	SR		ADC0 and shared ADC0/1 analog input voltage[2, 3]	—	$V_{SS\_HV\_ADV0} - 0.3$	—	$V_{DD\_HV\_ADV0} + 0.3$	V
V_{INAN1}	SR		ADC1 analog input voltage[2, 4]	—	$V_{SS\_HV\_ADV1} - 0.3$	—	$V_{DD\_HV\_ADV1} + 0.3$	V
f_{CK}	SR	—	ADC clock frequency (depends on ADC configuration) (The duty cycle depends on AD_clk[5] frequency)	—	3[6]	—	60	MHz
f_s	SR	—	Sampling frequency	—	—	—	1.53	MHz
t_{ADC_S}	—	D	Sample time[7]	f_{ADC} = 20 MHz, INPSAMP = 3	125	—	—	ns
				f_{ADC} = 9 MHz, INPSAMP = 255	—	—	28.2	µs
t_{ADC_C}	—	P	Conversion time[8]	f_{ADC} = 20 MHz[9], INPCMP = 1	0.650	—	—	µs
t_{ADC_PU}	SR	—	ADC power-up delay (time needed for ADC to settle exiting from software power down; PWDN bit = 0)	—	—	—	1.5	µs
C_S[10]	—	D	ADC input sampling capacitance	—	—	—	2.5	pF
C_{P1}[10]	—	D	ADC input pin capacitance 1	—	—	—	3	pF
C_{P2}[10]	—	D	ADC input pin capacitance 2	—	—	—	1	pF

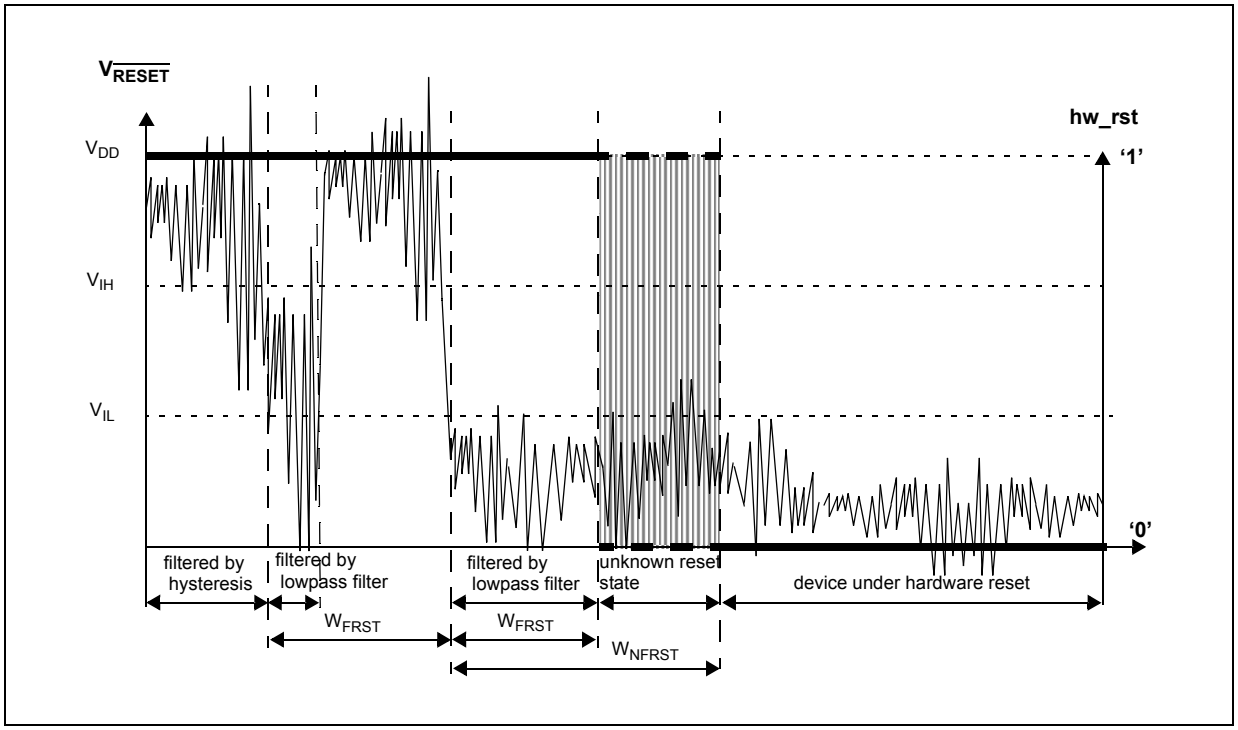

Figure 20. Noise filtering on reset signal

Table 36. $\overline{\text{RESET}}$ electrical characteristics

Symbol		C	Parameter	Conditions[1]	Value			Unit
					Min	Typ	Max	
V_{IH}	SR	P	Input High Level CMOS (Schmitt Trigger)	—	$0.65V_{DD}$	—	$V_{DD}+0.4$	V
V_{IL}	SR	P	Input low Level CMOS (Schmitt Trigger)	—	–0.4	—	$0.35V_{DD}$	V
V_{HYS}	CC	C	Input hysteresis CMOS (Schmitt Trigger)	—	$0.1V_{DD}$	—	—	V
V_{OL}	CC	P	Output low level	Push Pull, I_{OL} = 2mA, V_{DD} = 5.0 V ± 10%, PAD3V5V = 0 (recommended)	—	—	$0.1V_{DD}$	V
				Push Pull, I_{OL} = 1mA, V_{DD} = 5.0 V ± 10%, PAD3V5V = 1[2]	—	—	$0.1V_{DD}$	
				Push Pull, I_{OL} = 1mA, V_{DD} = 3.3 V ± 10%, PAD3V5V = 1 (recommended)	—	—	0.5	

Table 36. $\overline{\text{RESET}}$ electrical characteristics (continued)

Symbol		C	Parameter	Conditions[1]	Value			Unit
					Min	Typ	Max	
t_{tr}	CC	D	Output transition time output pin[3] MEDIUM configuration	C_L = 25pF, V_{DD} = 5.0 V ± 10%, PAD3V5V = 0	—	—	10	ns
				C_L = 50pF, V_{DD} = 5.0 V ± 10%, PAD3V5V = 0	—	—	20	
				C_L = 100pF, V_{DD} = 5.0 V ± 10%, PAD3V5V = 0	—	—	40	
				C_L = 25pF, V_{DD} = 3.3 V ± 10%, PAD3V5V = 1	—	—	12	
				C_L = 50pF, V_{DD} = 3.3 V ± 10%, PAD3V5V = 1	—	—	25	
				C_L = 100pF, V_{DD} = 3.3 V ± 10%, PAD3V5V = 1	—	—	40	
W_{FRST}	SR	P	$\overline{\text{RESET}}$ input filtered pulse	—	—	—	40	ns
W_{NFRST}	SR	P	$\overline{\text{RESET}}$ input not filtered pulse	—	500	—	—	ns
t_{POR}	CC	D	Maximum delay before internal reset is released after all V_{DD_HV} reach nominal supply	Monotonic V_{DD_HV} supply ramp	—	—	1	ms
$\lvert I_{WPU} \rvert$	CC	P	Weak pull-up current absolute value	V_{DD} = 3.3 V ± 10%, PAD3V5V = 1	10	—	150	µA
				V_{DD} = 5.0 V ± 10%, PAD3V5V = 0	10	—	150	
				V_{DD} = 5.0 V ± 10%, PAD3V5V = 1[4]	10	—	250	

1 V_{DD} = 3.3 V ± 10% / 5.0 V ± 10%, T_A = –40 °C to $T_{A\ MAX}$, unless otherwise specified

2 This is a transient configuration during power-up, up to the end of reset PHASE2 (refer to RGM module section of device reference manual).

3 C_L includes device and package capacitance (C_{PKG} < 5 pF).

4 The configuration PAD3V5 = 1 when V_{DD} = 5 V is only transient configuration during power-up. All pads but RESET and Nexus output (MDOx, EVTO, MCKO) are configured in input or in high impedance state.

3.17.2 IEEE 1149.1 interface timing

Table 37. JTAG pin AC electrical characteristics

No.	Symbol		C	Parameter	Conditions	Value		Unit
						Min	Max	
1	t_{JCYC}	CC	D	TCK cycle time	—	100	—	ns
2	t_{JDC}	CC	D	TCK clock pulse width (measured at $V_{DD\_HV\_IOx}$/2)	—	40	60	ns
3	$t_{TCKRISE}$	CC	D	TCK rise and fall times (40% – 70%)	—	—	3	ns
4	t_{TMSS}, t_{TDIS}	CC	D	TMS, TDI data setup time	—	5	—	ns

4 Package characteristics

4.1 Package mechanical data

4.1.1 144 LQFP mechanical outline drawing

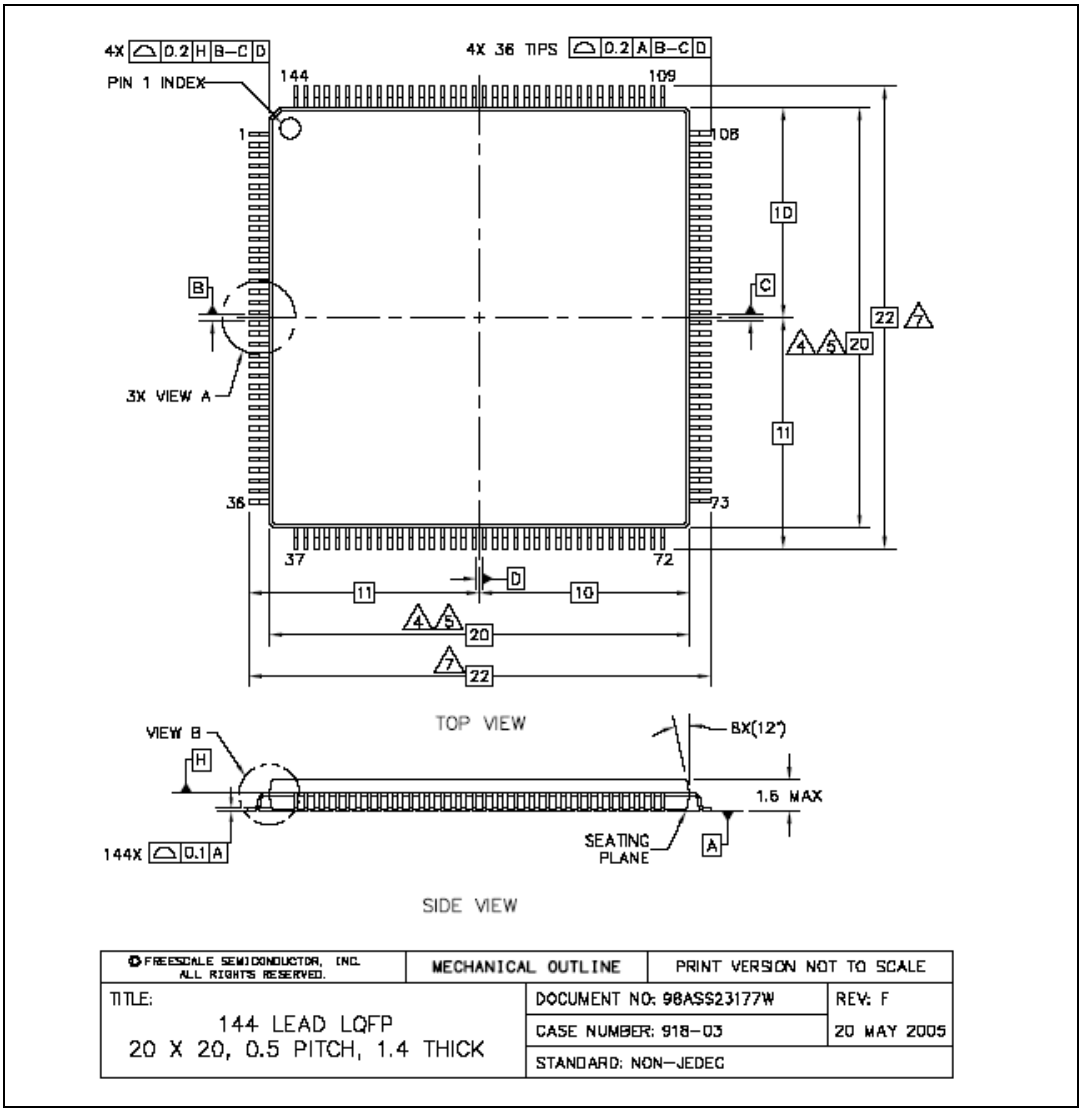

Figure 37. 144 LQFP package mechanical drawing (part 1)

4.1.2 100 LQFP mechanical outline drawing

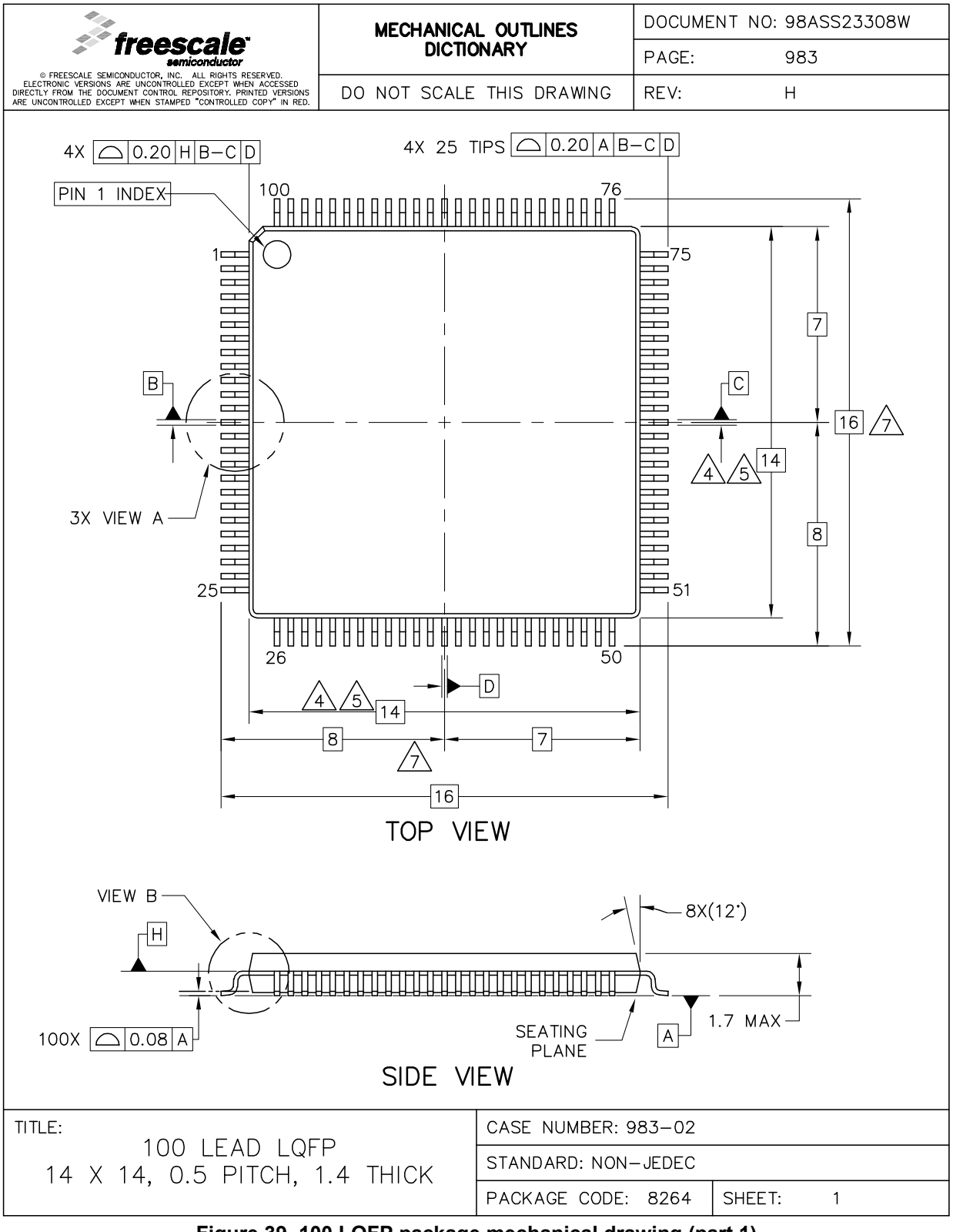

Figure 39. 100 LQFP package mechanical drawing (part 1)

Table 42. Revision history (continued)

Revision	Date	Substantive changes
Rev. 7	07-Apr-2011	Formatting and editorial changes throughout Removed all content referencing Junction Temperature Sensor Section 1, “Introduction: changed title (was: Overview); reorganized contents MPC5604P device comparison: • ADC feature: changed “16 channels” to “15-channel”; added footnote to to indicate that four channels are shared between the two ADCs • removed MPC5602P column • indicated that data flash memory is an optional feature • indicated that FlexRay is an optional feature • changed “dual channel” to “selectable single or dual channel support” in FlexRay footnote • updated “eTimer” feature • updated footnote relative to “Digital power supply” feature Updated MPC5604P block diagram Added MPC5604P series block summary Added Section 1.5, “Feature details Section 2.1, “Package pinouts: removed alternate functions from pinout diagrams Supply pins: updated descriptions of power supply pins (1.2 V) System pins: updated table Pin muxing: added rows “B[4]” and “B[5] Section 3.3, “Absolute maximum ratings: added voltage specifications to titles of Figure 4 and Figure 5; in Table 7, changed row “V_{SS_HV} / Digital Ground” to “V_{SS} / Device Ground”; updated symbols Section 3.4, “Recommended operating conditions: added voltage specifications to titles of Figure 6 and Figure 7 Recommended operating conditions (5.0 V), and Recommended operating conditions (3.3 V): changed row “V_{SS_HV} / Digital Ground” to “V_{SS} / Device Ground”; updated symbols Updated Section 3.5.1, “Package thermal characteristics Updated Section 3.6, “Electromagnetic interference (EMI) characteristics Section 3.8.1, “Voltage regulator electrical characteristics: amended titles of Table 15 and Table 17 Voltage regulator electrical characteristics (configuration without resistor on base) and Voltage regulator electrical characteristics (configuration with resistor on base): updated symbol and values for $V_{DD\_LV\_REGCOR}$ Low voltage monitor electrical characteristics: Updated $V_{MLVDDOK\_H}$ max value—was 1.15 V; is 1.145 V Section 3.10, “DC electrical characteristics: reorganized contents Updated Section 3.10.1, “NVUSRO register (includes adding “NVUSRO[OSCILLATOR_MARGIN] field description” table Supply current (5.0 V, NVUSRO[PAD3V5V] = 0): updated symbols

Table 42. Revision history (continued)

Revision	Date	Substantive changes
Rev. 8	23-May-2012	Section 1.5.4, “Flash memory: Changed “Data flash memory: 32-bit ECC” to “Data flash memory: 64-bit ECC” Figure 42 (Commercial product code structure), replaced "C = 60 MHz, 5 V" and "D = 60 MHz, 3.3 V" with respectively "C = 40 MHz, 5 V" and "D = 40 MHz, 3.3 V" Table 7 (Absolute maximum ratings), updated TV_{DD} parameter, the minimum value to 3.0 V/s and the maximum value to 0.5 V/µs Table 5 (Pin muxing), changed the description in the column "I/O direction" from "I/O" to "O" for the following port pins: A[10] with function B[0] A[11] with function A[0] A[11] with function A[2] A[12] with function A[2] A[12] with function B[2] A[13] with function B[2] C[7] with function A[1] C[10] with function A[3] C[15] with function A[1] D[0] with function B[1] D[10] with function A[0] D[11] with function B[0] D[13] with function A[1] D[14] with function B[1] Updated Section 3.8.1, “Voltage regulator electrical characteristics Added Table 25 (I/O consumption) Section 3.10, DC electrical characteristics: deleted references to “oscillator margin” deleted subsection “NVUSRO[OSCILLATOR_MARGIN] field description” Table 19 (DC electrical characteristics (5.0 V, NVUSRO[PAD3V5V] = 0)), added IPU row for $\overline{\text{RESET}}$ pin Table 21 (DC electrical characteristics (3.3 V, NVUSRO[PAD3V5V] = 1)), added IPU row for $\overline{\text{RESET}}$ pin Table 31 (ADC conversion characteristics), added V_{INAN} entry Removed “Order codes” table