MC9S12DP256B
Device User Guide
V02.14
Covers also

MC9S12DT256C, MC9S12DJ256C,
MC9S12DG256C, MC9S12DT256B,
MC9S12DJ256B, MC9S12DG256B
MC9S12A256B

Original Release Date: 29 Mar 2001
Revised: Mar 5, 2003
Motorola, Inc

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Revision History

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Preface

The Device User Guide provides information about the MC9S12DP256B device made up of standard HCS12 blocks and the HCS12 processor core.

Table 0-1 and Table 0-2 show the availability of peripheral modules on the various derivatives. For details about the compatibility within the MC9S12D-Family refer also to engineering bulletin EB386.

### Table 0-1 Derivative Differences MC9S12D256B

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<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>112 LQFP</td>
<td>112 LQFP</td>
<td>112 LQFP/80 QFP</td>
<td>112 LQFP/80 QFP</td>
<td>112 LQFP/80 QFP</td>
</tr>
<tr>
<td>Mask set</td>
<td>0/1K79X</td>
<td>0/1K79X</td>
<td>0/1K79X</td>
<td>0/1K79X</td>
<td>0/1K79X</td>
</tr>
<tr>
<td>Temp Options</td>
<td>M, V, C</td>
<td>M, V, C</td>
<td>M, V, C</td>
<td>M, V, C</td>
<td>C</td>
</tr>
<tr>
<td>package Code</td>
<td>PV</td>
<td>PV</td>
<td>PV/FU</td>
<td>PV</td>
<td>PV/FU</td>
</tr>
<tr>
<td>Notes</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
</tr>
</tbody>
</table>

### Table 0-2 Derivative Differences MC9S12D256C

<table>
<thead>
<tr>
<th>Generic device</th>
<th>MC9S12DP256C</th>
<th>MC9S12DT256C</th>
<th>MC9S12DJ256C</th>
<th>MC9S12DG256C</th>
</tr>
</thead>
<tbody>
<tr>
<td># of CANs</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CAN0</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CAN1</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN2</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN3</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN4</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>J1850/BDLC</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>112 LQFP</td>
<td>112 LQFP</td>
<td>112 LQFP/80 QFP</td>
<td>112 LQFP/80 QFP</td>
</tr>
<tr>
<td>Mask set</td>
<td>2K79X</td>
<td>2K79X</td>
<td>2K79X</td>
<td>2K79X</td>
</tr>
<tr>
<td>Temp Options</td>
<td>M, V, C</td>
<td>M, V, C</td>
<td>M, V, C</td>
<td>M, V, C</td>
</tr>
<tr>
<td>package Code</td>
<td>PV</td>
<td>PV</td>
<td>PV/FU</td>
<td>PV</td>
</tr>
<tr>
<td>Notes</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
<td>An errata exists contact Sales office</td>
</tr>
</tbody>
</table>
Table 0-3 shows the defects fixed on maskset 2K79X (MC9S12DP256C)

<table>
<thead>
<tr>
<th>Defect</th>
<th>Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUCts00510</td>
<td>SCI interrupt asserts only if odd number of interrupts active</td>
</tr>
<tr>
<td>MUCts00604</td>
<td>Security in Normal Single Chip mode</td>
</tr>
<tr>
<td>MUCts00603</td>
<td>Security in Normal Single Chip mode</td>
</tr>
</tbody>
</table>

This document is part of the customer documentation. A complete set of device manuals also includes the HCS12 Core User Guide and all the individual Block User Guides of the implemented modules. In an effort to reduce redundancy all module specific information is located only in the respective Block User Guide. If applicable, special implementation details of the module are given in the block description sections of this document.

Figure 0-1 Order Part Number Example

See Table 0-4 for names and versions of the referenced documents throughout the Device User Guide.

<table>
<thead>
<tr>
<th>User Guide</th>
<th>Version</th>
<th>Document Order Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCS12 V1.5 Core User Guide</td>
<td>1.2</td>
<td>HCS12COREUG</td>
</tr>
<tr>
<td>CRG Block User Guide</td>
<td>V02</td>
<td>S12CRGV2/D</td>
</tr>
<tr>
<td>ECT_16B8C Block User Guide</td>
<td>V01</td>
<td>S12ECT16B8CV1/D</td>
</tr>
<tr>
<td>ATD_10B8C Block User Guide</td>
<td>V02</td>
<td>S12ATD10B8CV2/D</td>
</tr>
<tr>
<td>IIC Block User Guide</td>
<td>V02</td>
<td>S12IICV2/D</td>
</tr>
<tr>
<td>SCI Block User Guide</td>
<td>V02</td>
<td>S12SCIV2/D</td>
</tr>
<tr>
<td>SPI Block User Guide</td>
<td>V02</td>
<td>S12SPIV2/D</td>
</tr>
<tr>
<td>PWM_8B8C Block User Guide</td>
<td>V01</td>
<td>S12PWM8B8CV1/D</td>
</tr>
<tr>
<td>FTS256K Block User Guide</td>
<td>V02</td>
<td>S12FTS256KV2/D</td>
</tr>
<tr>
<td>EETS4K Block User Guide</td>
<td>V02</td>
<td>S12EETS4KV2/D</td>
</tr>
<tr>
<td>BDLC Block User Guide</td>
<td>V01</td>
<td>S12BDLCV1/D</td>
</tr>
<tr>
<td>MSCAN Block User Guide</td>
<td>V02</td>
<td>S12MSCANV2/D</td>
</tr>
<tr>
<td>VREG Block User Guide</td>
<td>V01</td>
<td>S12VREGV1/D</td>
</tr>
<tr>
<td>PIM_9DP256 Block User Guide</td>
<td>V02</td>
<td>S12PIM9DP256V2/D</td>
</tr>
</tbody>
</table>
Section 1 Introduction

1.1 Overview

The MC9S12DP256 microcontroller unit (MCU) is a 16-bit device composed of standard on-chip peripherals including a 16-bit central processing unit (HCS12 CPU), 256K bytes of Flash EEPROM, 12K bytes of RAM, 4K bytes of EEPROM, two asynchronous serial communications interfaces (SCI), three serial peripheral interfaces (SPI), an 8-channel IC/OC enhanced capture timer, two 8-channel, 10-bit analog-to-digital converters (ADC), an 8-channel pulse-width modulator (PWM), a digital Byte Data Link Controller (BDLC), 29 discrete digital I/O channels (Port A, Port B, Port K and Port E), 20 discrete digital I/O lines with interrupt and wakeup capability, five CAN 2.0 A, B software compatible modules (MSCAN12), and an Inter-IC Bus. The MC9S12DP256 has full 16-bit data paths throughout. However, the external bus can operate in an 8-bit narrow mode so single 8-bit wide memory can be interfaced for lower cost systems. The inclusion of a PLL circuit allows power consumption and performance to be adjusted to suit operational requirements.

1.2 Features

- **HCS12 Core**
  - 16-bit HCS12 CPU
    i. Upward compatible with M68HC11 instruction set
    ii. Interrupt stacking and programmer’s model identical to M68HC11
    iii. Instruction queue
    iv. Enhanced indexed addressing
  - MEBI (Multiplexed External Bus Interface)
  - MMC (Module Mapping Control)
  - INT (Interrupt control)
  - BKP (Breakpoints)
  - BDM (Background Debug Mode)
- **CRG (low current oscillator, PLL, reset, clocks, COP watchdog, real time interrupt, clock monitor)**
- **8-bit and 4-bit ports with interrupt functionality**
  - Digital filtering
  - Programmable rising or falling edge trigger
- **Memory**
  - 256K Flash EEPROM
  - 4K byte EEPROM
  - 12K byte RAM
• Two 8-channel Analog-to-Digital Converters
  – 10-bit resolution
  – External conversion trigger capability
• Five 1M bit per second, CAN 2.0 A, B software compatible modules
  – Five receive and three transmit buffers
  – Flexible identifier filter programmable as 2 x 32 bit, 4 x 16 bit or 8 x 8 bit
  – Four separate interrupt channels for Rx, Tx, error and wake-up
  – Low-pass filter wake-up function
  – Loop-back for self test operation
• Enhanced Capture Timer
  – 16-bit main counter with 7-bit prescaler
  – 8 programmable input capture or output compare channels
  – Two 8-bit or one 16-bit pulse accumulators
• 8 PWM channels
  – Programmable period and duty cycle
  – 8-bit 8-channel or 16-bit 4-channel
  – Separate control for each pulse width and duty cycle
  – Center-aligned or left-aligned outputs
  – Programmable clock select logic with a wide range of frequencies
  – Fast emergency shutdown input
  – Usable as interrupt inputs
• Serial interfaces
  – Two asynchronous Serial Communications Interfaces (SCI)
  – Three Synchronous Serial Peripheral Interface (SPI)
• Byte Data Link Controller (BDLC)
  – SAE J1850 Class B Data Communications Network Interface Compatible and ISO Compatible for Low-Speed (<125 Kbps) Serial Data Communications in Automotive Applications
• Inter-IC Bus (IIC)
  – Compatible with I2C Bus standard
  – Multi-master operation
  – Software programmable for one of 256 different serial clock frequencies
• 112-Pin LQFP package
  – I/O lines with 5V input and drive capability
– 5V A/D converter inputs
– Operation at 50MHz equivalent to 25MHz Bus Speed
– Development support
– Single-wire background debug™ mode (BDM)
– On-chip hardware breakpoints

1.3 Modes of Operation

User modes

• Normal and Emulation Operating Modes
  – Normal Single-Chip Mode
  – Normal Expanded Wide Mode
  – Normal Expanded Narrow Mode
  – Emulation Expanded Wide Mode
  – Emulation Expanded Narrow Mode
• Special Operating Modes
  – Special Single-Chip Mode with active Background Debug Mode
  – Special Test Mode (Motorola use only)
  – Special Peripheral Mode (Motorola use only)

Low power modes

• Stop Mode
• Pseudo Stop Mode
• Wait Mode
1.4 Block Diagram

Figure 1-1 shows a block diagram of the MC9S12DP256B device.
Figure 1-1 MC9S12DP256B Block Diagram
1.5 Device Memory Map

Table 1-1 and Figure 1-2 show the device memory map of the MC9S12DP256B after reset. Note that after reset the bottom 1k of the EEPROM ($0000 - $03FF) are hidden by the register space.

### Table 1-1 Device Memory Map

<table>
<thead>
<tr>
<th>Address</th>
<th>Module</th>
<th>Size (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0000 - $0017</td>
<td>CORE (Ports A, B, E, Modes, Inits, Test)</td>
<td>24</td>
</tr>
<tr>
<td>$0018 - $0019</td>
<td>Reserved</td>
<td>2</td>
</tr>
<tr>
<td>$001A - $001B</td>
<td>Device ID register (PARTID)</td>
<td>2</td>
</tr>
<tr>
<td>$001C - $001F</td>
<td>CORE (MEMSIZ, IRQ, HPRIO)</td>
<td>4</td>
</tr>
<tr>
<td>$0020 - $0027</td>
<td>Reserved</td>
<td>8</td>
</tr>
<tr>
<td>$0028 - $002F</td>
<td>CORE (Background Debug Mode)</td>
<td>8</td>
</tr>
<tr>
<td>$0030 - $0033</td>
<td>CORE (PPAGE, Port K)</td>
<td>4</td>
</tr>
<tr>
<td>$0034 - $003F</td>
<td>Clock and Reset Generator (PLL, RTI, COP)</td>
<td>12</td>
</tr>
<tr>
<td>$0040 - $007F</td>
<td>Enhanced Capture Timer 16-bit 8 channels</td>
<td>64</td>
</tr>
<tr>
<td>$0080 - $009F</td>
<td>Analog to Digital Converter 10-bit 8 channels</td>
<td>32</td>
</tr>
<tr>
<td>$00A0 - $00C7</td>
<td>Pulse Width Modulator 8-bit 8 channels (PWM)</td>
<td>40</td>
</tr>
<tr>
<td>$00C8 - $00CF</td>
<td>Serial Communications Interface 0 (SCI0)</td>
<td>8</td>
</tr>
<tr>
<td>$00D0 - $00DF</td>
<td>Serial Communications Interface 0 (SCI1)</td>
<td>8</td>
</tr>
<tr>
<td>$0100 - $011F</td>
<td>Flash Control Register</td>
<td>16</td>
</tr>
<tr>
<td>$0110 - $011B</td>
<td>EEPROM Control Register</td>
<td>12</td>
</tr>
<tr>
<td>$011C - $011F</td>
<td>Reserved</td>
<td>4</td>
</tr>
<tr>
<td>$0128 - $013F</td>
<td>Analog to Digital Converter 10-bit 8 channels</td>
<td>32</td>
</tr>
<tr>
<td>$0140 - $017F</td>
<td>Motorola Scalable Can (CAN0)</td>
<td>64</td>
</tr>
<tr>
<td>$0180 - $01BF</td>
<td>Motorola Scalable Can (CAN1)</td>
<td>64</td>
</tr>
<tr>
<td>$01C0 - $01FF</td>
<td>Motorola Scalable Can (CAN2)</td>
<td>64</td>
</tr>
<tr>
<td>$0200 - $023F</td>
<td>Motorola Scalable Can (CAN3)</td>
<td>64</td>
</tr>
<tr>
<td>$0240 - $027F</td>
<td>Port Integration Module (PIM)</td>
<td>64</td>
</tr>
<tr>
<td>$0280 - $02BF</td>
<td>Motorola Scalable Can (CAN4)</td>
<td>64</td>
</tr>
<tr>
<td>$02C0 - $03FF</td>
<td>Reserved</td>
<td>320</td>
</tr>
<tr>
<td>$0000 - $0FFF</td>
<td>EEPROM array</td>
<td>4096</td>
</tr>
<tr>
<td>$1000 - $3FFF</td>
<td>RAM array</td>
<td>12288</td>
</tr>
<tr>
<td>$4000 - $7FFF</td>
<td>Fixed Flash EEPROM array incl. 0.5K, 1K, 2K or 4K Protected Sector at start</td>
<td>16384</td>
</tr>
<tr>
<td>$8000 - $BFFF</td>
<td>Flash EEPROM Page Window</td>
<td>16384</td>
</tr>
</tbody>
</table>
### Table 1-1  Device Memory Map

<table>
<thead>
<tr>
<th>Address</th>
<th>Module</th>
<th>Size (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C000 - $FFFF</td>
<td>Fixed Flash EEPROM array incl. 0.5K, 1K, 2K or 4K Protected Sector at end and 256 bytes of Vector Space at $FF80 - $FFFF</td>
<td>16384</td>
</tr>
</tbody>
</table>
Figure 1-2 MC9S12DP256B Memory Map

- **$0000** to **$03FF**: REGISTERS (Mappable to any 2k Block within the first 32K)
- **$0000** to **$0FFF**: 4K Bytes EEPROM (Mappable to any 4K Block)
- **$1000** to **$3FFF**: 12K Bytes RAM (Mappable to any 16K and alignable to top or bottom)
- **$4000** to **$7FFF**: 16K Fixed Flash Page $3E = 62 (This is dependant on the state of the ROMHM bit)
- **$8000** to **$BFFF**: 16K Page Window 16 x 16K Flash EEPROM pages
- **$C000** to **$FFFF**: 16K Fixed Flash Page $3F = 63
- **$FF00** to **$FFFF**: BDM (if active)

* Assuming that a '0' was driven onto port K bit 7 during MCU is reset into normal expanded wide or narrow mode.
### 1.6 Detailed Register Map

The following tables show the detailed register map of the MC9S12DP256B.

#### $0000 - $000F

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Read:</th>
<th>Write:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0000</td>
<td>PORTA</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0001</td>
<td>PORTB</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0002</td>
<td>DDRA</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0003</td>
<td>DDRB</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0004</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0005</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0006</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0007</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0008</td>
<td>PORTE</td>
<td>Bit 7</td>
<td>6 5 4 3 2 Bit 1 Bit 0</td>
</tr>
<tr>
<td>$0009</td>
<td>DDRE</td>
<td>Bit 7</td>
<td>6 5 4 3 2 Bit 2 0 0</td>
</tr>
<tr>
<td>$000A</td>
<td>PEAR</td>
<td>NOACCE</td>
<td>PIPOE NECLK LSTRE RDWE 0 0</td>
</tr>
<tr>
<td>$000B</td>
<td>MODE</td>
<td>MODC</td>
<td>MODB MODA 0 IVIS 0 EMK EME</td>
</tr>
<tr>
<td>$000C</td>
<td>PUCR</td>
<td>PUPKE</td>
<td>0 0 PUPEE 0 0 PUPBE PUPAE</td>
</tr>
<tr>
<td>$000D</td>
<td>RDRIV</td>
<td>RDPK</td>
<td>0 0 RDPE 0 0 RDPB RDPA</td>
</tr>
<tr>
<td>$000E</td>
<td>EBICTL</td>
<td>0</td>
<td>0 0 0 0 0 0 0 ESTR</td>
</tr>
<tr>
<td>$000F</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

#### MEBI map 1 of 3 (Core User Guide)

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Read:</th>
<th>Write:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0000</td>
<td>PORTA</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0001</td>
<td>PORTB</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0002</td>
<td>DDRA</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0003</td>
<td>DDRB</td>
<td>Bit 7</td>
<td>6 5 4 3 2 1 Bit 0</td>
</tr>
<tr>
<td>$0004</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0005</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0006</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0007</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>$0008</td>
<td>PORTE</td>
<td>Bit 7</td>
<td>6 5 4 3 2 Bit 1 Bit 0</td>
</tr>
<tr>
<td>$0009</td>
<td>DDRE</td>
<td>Bit 7</td>
<td>6 5 4 3 2 Bit 2 0 0</td>
</tr>
<tr>
<td>$000A</td>
<td>PEAR</td>
<td>NOACCE</td>
<td>PIPOE NECLK LSTRE RDWE 0 0</td>
</tr>
<tr>
<td>$000B</td>
<td>MODE</td>
<td>MODC</td>
<td>MODB MODA 0 IVIS 0 EMK EME</td>
</tr>
<tr>
<td>$000C</td>
<td>PUCR</td>
<td>PUPKE</td>
<td>0 0 PUPEE 0 0 PUPBE PUPAE</td>
</tr>
<tr>
<td>$000D</td>
<td>RDRIV</td>
<td>RDPK</td>
<td>0 0 RDPE 0 0 RDPB RDPA</td>
</tr>
<tr>
<td>$000E</td>
<td>EBICTL</td>
<td>0</td>
<td>0 0 0 0 0 0 0 ESTR</td>
</tr>
<tr>
<td>$000F</td>
<td>Reserved</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

#### $0010 - $0014

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Read:</th>
<th>Write:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0010</td>
<td>INITRM</td>
<td>RAM15</td>
<td>RAM14 RAM13 RAM12 RAM11 0 0 RAMHAL</td>
</tr>
<tr>
<td>$0011</td>
<td>INITRG</td>
<td>0</td>
<td>REG14 REG13 REG12 REG11 0 0 0</td>
</tr>
</tbody>
</table>

#### MMC map 1 of 4 (Core User Guide)
### MMC map 1 of 4 (Core User Guide)

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Read:</th>
<th>Write:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0010</td>
<td>INITEE</td>
<td>Bit 7</td>
<td>EE15</td>
</tr>
<tr>
<td>$0011</td>
<td>MISC</td>
<td>Bit 6</td>
<td>EE14</td>
</tr>
<tr>
<td>$0012</td>
<td>MISC</td>
<td>Bit 5</td>
<td>EE13</td>
</tr>
<tr>
<td>$0013</td>
<td>MISC</td>
<td>Bit 4</td>
<td>EE12</td>
</tr>
<tr>
<td>$0014</td>
<td>MISC</td>
<td>Bit 3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bit 1</td>
<td>0</td>
</tr>
<tr>
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MC9S12DP256B Device User Guide — V02.14

$00A0 - $00C7

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### Notes

- **PWMIF**: PWM Interrupt Flag
- **PWMIE**: PWM Interrupt Enable
- **PWMRS**: PWM Rising Edge
- **TRT**: Trigger Enable
- **PWM7IN**: PWM 7 Input
- **PWM7INL**: PWM 7 Input Low
- **PWM7ENA**: PWM 7 Input Enable
### $00D8 - $00DF

**SPI0 (Serial Peripheral Interface)**

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### $00E0 - $00E7

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**$0140 - $017F**

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**Table 1-2** Detailed MSCAN Foreground Receive and Transmit Buffer Layout

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*Table 1-2* Detailed MSCAN Foreground Receive and Transmit Buffer Layout
### Table 1-2  Detailed MSCAN Foreground Receive and Transmit Buffer Layout

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<th>Bit 5</th>
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### CAN1 (Motorola Scalable CAN - MSCAN)

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<td>$0180</td>
<td>CAN1CTL0</td>
<td>Read: RXFRM, RXACT, CSWAI, SYNCH, TIME, WUPE, SLPRQ, INITRQ</td>
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<td>Write: CANE, CLKSRC, LOOPB, LISTEN, 0, WUPM, SLPACK, INITAK</td>
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<td>$0181</td>
<td>CAN1CTL1</td>
<td>Read: SJW1, SJW0, BRP5, BRP4, BRP3, BRP2, BRP1, BRP0</td>
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<td>Write: SAMP, TSEG22, TSEG21, TSEG20, TSEG13, TSEG12, TSEG11, TSEG10</td>
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<td>CAN1BTR0</td>
<td>Read: WUPIF, CSCIF, RSTAT1, RSTATE0, TSTATE1, TSTATE0, OVRIF, RXF</td>
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<td>Write: WUPIE, CSCIE, RSTATE1, RSTATE0, TSTATE1, TSTATE0, OVRIE, RXFIE</td>
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<td>Write: 0, 0, 0, 0, 0, 0, TXEIE2, TXEIE1, TXEIE0</td>
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<td>Read: 0, 0, 0, 0, 0, 0, 0, ABTRQ2, ABTRQ1, ABTRQ0</td>
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<td>Write: 0, 0, 0, 0, 0, 0, ABTA2, ABTA1, ABTA0</td>
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<td>Read: 0, 0, 0, 0, 0, 0, TX2, TX1, TX0</td>
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<td>Write: 0, 0, 0, 0, 0, 0, TX2E2, TXE1, TXE0</td>
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<td>Read: 0, 0, 0, 0, 0, 0, 0, IDAM1, IDAM0, 0, IDHIT2, IDHIT1, IDHIT0</td>
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<td>Write: 0, 0, 0, 0, 0, 0, IDHIT2, IDHIT1, IDHIT0</td>
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<td>CAN1TARQ</td>
<td>Read: RXERR7, RXERR6, RXERR5, RXERR4, RXERR3, RXERR2, RXERR1, RXERR0</td>
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<td>Write: RXERR7, RXERR6, RXERR5, RXERR4, RXERR3, RXERR2, RXERR1, RXERR0</td>
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<td>CAN1TBSEL</td>
<td>Read: AC7, AC6, AC5, AC4, AC3, AC2, AC1, AC0</td>
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<td>Write: AC7, AC6, AC5, AC4, AC3, AC2, AC1, AC0</td>
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<td>Read: AC7, AC6, AC5, AC4, AC3, AC2, AC1, AC0</td>
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<td>Write: AC7, AC6, AC5, AC4, AC3, AC2, AC1, AC0</td>
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**Note:** The table above shows the address, name, and read/write permissions for various registers in the MC9S12DP256B device. Each register is associated with specific bits that control various aspects of the CAN1 interface, such as clock settings, error flags, and transmission control.
### CAN1 (Motorola Scalable CAN - MSCAN)

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<th>Address</th>
<th>Name</th>
<th>Description</th>
<th>Bit 7</th>
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<th>Bit 5</th>
<th>Bit 4</th>
<th>Bit 3</th>
<th>Bit 2</th>
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<td>Read: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0</td>
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<td>$01AF</td>
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<td>Write: FOREGROUND TRANSMIT BUFFER see Table 1-2</td>
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<td>Write: CANE CLKSRC LOOPB LISTEN WUPM SLPAK INITAK</td>
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$01C0 - $01FF CAN2 (Motorola Scalable CAN - MSCAN)

**FOREGROUND RECEIVE BUFFER** see Table 1-2

**FOREGROUND TRANSMIT BUFFER** see Table 1-2
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#### Bit 7 Bit 6 Bit 5 Bit 4 Bit 3 Bit 2 Bit 1 Bit 0

- $0200 CAN3CTL0: RXFRM RXACT CSWAI SYNCH TIME WUPE SLPRQ INITRQ
- $0201 CAN3CTL1: CANE CLKSRC LOOPB LISTEN 0 WUPM SLPAK INITAK
- $0202 CAN3BTR0: SJW1 SJW0 BRP5 BRP4 BRP3 BRP2 BRP1 BRP0
- $0203 CAN3BTR1: SAMP TSEG22 TSEG21 TSEG20 TSEG13 TSEG12 TSEG11 TSEG10
- $0204 CAN3RFLG: WUPIF CSCIF RSTAT1 RSTAT0 TSTATE1 TSTATE0 OVRIF RXF
- $0205 CAN3RIER: WUPIE CSCIE RSTATE1 RSTATE0 TSTATE1 TSTATE0 OVRIE RXFIE
- $0206 CAN3TFLG: 0 0 0 0 0 0 TXE2 TXE1 TXE0
- $0207 CAN3TIER: 0 0 0 0 0 0 TXEIE2 TXEIE1 TXEIE0
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- $0209 CAN3TAAR: 0 0 0 0 0 0 ABTA2 ABTA1 ABTA0
- $020A CAN3TBSEL: 0 0 0 0 0 0 TX2 TX1 TX0
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- $0211 CAN3IDAR1: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0
- $0212 CAN3IDAR2: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0
- $0213 CAN3IDAR3: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0
- $0214 CAN3IDMR0: AM7 AM6 AM5 AM4 AM3 AM2 AM1 AM0
- $0215 CAN3IDMR1: AM7 AM6 AM5 AM4 AM3 AM2 AM1 AM0
- $0216 CAN3IDMR2: AM7 AM6 AM5 AM4 AM3 AM2 AM1 AM0
- $0217 CAN3IDMR3: AM7 AM6 AM5 AM4 AM3 AM2 AM1 AM0
- $0218 CAN3IDAR4: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0
### $0200 - $023F

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#### PIM (Port Integration Module PIM_9DP256)

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### Notes

- CAN3IDAR5 - CAN3IDMR7:
  - Read: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0
  - Write: AC7 AC6 AC5 AC4 AC3 AC2 AC1 AC0

- CAN3RXFG:
  - Read: FOREGROUND RECEIVE BUFFER see Table 1-2

- CAN3TXFG:
  - Read: FOREGROUND TRANSMIT BUFFER see Table 1-2
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### $0280 - \text{ $02BF}$

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### MC9S12DP256B Device User Guide — V02.14

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### Reserved space

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1.7 Part ID Assignments

The part ID is located in two 8-bit registers PARTIDH and PARTIDL (addresses $001A and $001B after reset). The read-only value is a unique part ID for each revision of the chip. Table 1-3 shows the assigned part ID number.

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NOTES:
1. The coding is as follows:
   Bit 15-12: Major family identifier
   Bit 11-8: Minor family identifier
   Bit 7-4: Major mask set revision number including FAB transfers
   Bit 3-0: Minor - non full - mask set revision

The device memory sizes are located in two 8-bit registers MEMSIZ0 and MEMSIZ1 (addresses $001C and $001D after reset). Table 1-4 shows the read-only values of these registers. Refer to section Module Mapping and Control (MMC) of HCS12 Core User Guide for further details.

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Section 2  Signal Description

This section describes signals that connect off-chip. It includes a pinout diagram, a table of signal properties, and detailed discussion of signals. It is built from the signal description sections of the Block User Guides of the individual IP blocks on the device.

2.1 Device Pinout

The MC9S12DP256B/MC9S12DT256/MC9S12DJ256 and MC9S12DG256 is available in a 112-pin low profile quad flat pack (LQFP) and MC9S12DJ256 is also available in a 80-pin quad flat pack (QFP). Most pins perform two or more functions, as described in the Signal Descriptions. Figure 2-1 and Figure 2-3 show the pin assignments.
Figure 2-1 Pin Assignments in 112-pin LQFP
Figure 2-2 Pin Assignments in 80-pin QFP for MC9S12DG256
Figure 2-3  Pin Assignments in 80-pin QFP for MC9S12DJ256

2.2 Signal Properties Summary

Table 2-1 summarizes the pin functionality. Signals shown in **bold** are not available in the 80 pin package.

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<th>Pin Name Funct. 3</th>
<th>Pin Name Funct. 4</th>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>N.A.</td>
<td>NA NA</td>
<td>Test Input</td>
</tr>
<tr>
<td>VREGEN</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>NA NA</td>
<td>Voltage Regulator Enable Input</td>
</tr>
<tr>
<td>XFC</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDPLL</td>
<td>NA NA</td>
<td>PLL Loop Filter</td>
</tr>
<tr>
<td>BKGD</td>
<td>TAGHI</td>
<td>MODC</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>Always Up Up</td>
<td>Background Debug, Tag High, Mode Input</td>
</tr>
<tr>
<td>PAD[15]</td>
<td>AN1[7]</td>
<td>ETRIG1</td>
<td>—</td>
<td>—</td>
<td>VDDA</td>
<td>None None</td>
<td>Port AD Input, Analog Input AN7 of ATD1, External Trigger Input of ATD1</td>
</tr>
<tr>
<td>PAD[14:8]</td>
<td>AN1[6:0]</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDA</td>
<td>None None</td>
<td>Port AD Inputs, Analog Inputs AN[6:0] of ATD1</td>
</tr>
<tr>
<td>PAD[7]</td>
<td>AN0[7]</td>
<td>ETRIG0</td>
<td>—</td>
<td>—</td>
<td>VDDA</td>
<td>None None</td>
<td>Port AD Input, Analog Input AN7 of ATD0, External Trigger Input of ATD0</td>
</tr>
<tr>
<td>PAD[6:0]</td>
<td>AN0[6:0]</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDA</td>
<td>None None</td>
<td>Port AD Inputs, Analog Inputs AN[6:0] of ATD0</td>
</tr>
<tr>
<td>PB[7:0]</td>
<td>ADDR[7:0]</td>
<td>DATA[7:0]</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PUCR Disabled</td>
<td>Port B I/O, Multiplexed Address/Data</td>
</tr>
<tr>
<td>PE7</td>
<td>NOACC</td>
<td>XCLKS</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PUCR Up</td>
<td>Port E I/O, Access, Clock Select</td>
</tr>
<tr>
<td>PE6</td>
<td>IPIPE1</td>
<td>MODB</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>While RESET pin is low: Down</td>
<td>Port E I/O, Pipe Status, Mode Input</td>
</tr>
<tr>
<td>PE5</td>
<td>IPIPE0</td>
<td>MODA</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>While RESET pin is low: Down</td>
<td>Port E I/O, Pipe Status, Mode Input</td>
</tr>
<tr>
<td>PE4</td>
<td>ECLK</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PUCR Up</td>
<td>Port E I/O, Bus Clock Output</td>
</tr>
<tr>
<td>PE3</td>
<td>LSTRB</td>
<td>TAGLO</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PUCR Up</td>
<td>Port E I/O, Byte Strobe, Tag Low</td>
</tr>
<tr>
<td>PE2</td>
<td>R/W</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PUCR Up</td>
<td>Port E I/O, R/W in expanded modes</td>
</tr>
<tr>
<td>PE1</td>
<td>IRQ</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>Always up</td>
<td>Port E Input, Maskable Interrupt</td>
</tr>
<tr>
<td>PE0</td>
<td>XIRQ</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td></td>
<td>Port E Input, Non Maskable Interrupt</td>
</tr>
<tr>
<td>PH7</td>
<td>KWH7</td>
<td>SS2</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH Disabled</td>
<td>Port H I/O, Interrupt, SS of SPI2</td>
</tr>
<tr>
<td>PH6</td>
<td>KWH6</td>
<td>SCK2</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH Disabled</td>
<td>Port H I/O, Interrupt, SCK of SPI2</td>
</tr>
<tr>
<td>Pin Name</td>
<td>Pin Name</td>
<td>Pin Name</td>
<td>Pin Name</td>
<td>Pin Name</td>
<td>Power Supply</td>
<td>Internal Pull Resistor</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>--------------</td>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PH5</td>
<td>KWH5</td>
<td>MOSI2</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, MOSI of SPI2</td>
</tr>
<tr>
<td>PH4</td>
<td>KWH4</td>
<td>MISO2</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, MISO of SPI2</td>
</tr>
<tr>
<td>PH3</td>
<td>KWH3</td>
<td>SST</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, SS of SPI1</td>
</tr>
<tr>
<td>PH2</td>
<td>KWH2</td>
<td>SCK1</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, SCK of SPI1</td>
</tr>
<tr>
<td>PH1</td>
<td>KWH1</td>
<td>MOSI1</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, MOSI of SPI1</td>
</tr>
<tr>
<td>PH0</td>
<td>KWH0</td>
<td>MISO1</td>
<td>—</td>
<td>—</td>
<td>VDDR</td>
<td>PERH/PPSH</td>
<td>Disabled Port H I/O, Interrupt, MISO of SPI1</td>
</tr>
<tr>
<td>PJ7</td>
<td>KWJ7</td>
<td>TXCAN4</td>
<td>SCL</td>
<td>TXCAN0</td>
<td>VDDX</td>
<td>PERJ/PPSJ</td>
<td>Up Port J I/O, Interrupt, TX of CAN4, SCL of IIC, TX of CAN0</td>
</tr>
<tr>
<td>PJ6</td>
<td>KWJ6</td>
<td>RXCAN4</td>
<td>SDA</td>
<td>RXCAN0</td>
<td>VDDX</td>
<td>PERJ/PPSJ</td>
<td>Up Port J I/O, Interrupt, RX of CAN4, SDA of IIC, RX of CAN0</td>
</tr>
<tr>
<td>PK7</td>
<td>ECS</td>
<td>ROMONE</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>PUCR</td>
<td>Up Port K I/O, Emulation Chip Select, ROM On Enable</td>
</tr>
<tr>
<td>PM7</td>
<td>TXCAN3</td>
<td>TXCAN4</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, TX of CAN3, TX of CAN4</td>
</tr>
<tr>
<td>PM6</td>
<td>RXCAN3</td>
<td>RXCAN4</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, RX of CAN3, RX of CAN4</td>
</tr>
<tr>
<td>PM5</td>
<td>TXCAN2</td>
<td>TXCAN0</td>
<td>TXCAN4</td>
<td>SCK0</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, TX of CAN2, CAN0, CAN4, SCK of SPI0</td>
</tr>
<tr>
<td>PM4</td>
<td>RXCAN2</td>
<td>RXCAN0</td>
<td>RXCAN4</td>
<td>MOSI0</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, RX of CAN2, CAN0, CAN4, MOSI of SPI0</td>
</tr>
<tr>
<td>PM3</td>
<td>TXCAN1</td>
<td>TXCAN0</td>
<td>—</td>
<td>SS0</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, TX of CAN1, CAN0, SS of SPI0</td>
</tr>
<tr>
<td>PM2</td>
<td>RXCAN1</td>
<td>RXCAN0</td>
<td>—</td>
<td>MISO0</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, RX of CAN1, CAN0, MISO of SPI0</td>
</tr>
<tr>
<td>PM1</td>
<td>TXCAN0</td>
<td>TXB</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, TX of CAN0, TX of BDLC</td>
</tr>
<tr>
<td>PM0</td>
<td>RXCAN0</td>
<td>RXB</td>
<td>—</td>
<td>—</td>
<td>VDDX</td>
<td>PERM/PPSM</td>
<td>Disabled Port M I/O, RX of CAN0, RX of BDLC</td>
</tr>
<tr>
<td>PP7</td>
<td>KWP7</td>
<td>PWM7</td>
<td>SCK2</td>
<td>—</td>
<td>VDDX</td>
<td>PERP/PPSP</td>
<td>Disabled Port P I/O, Interrupt, Channel 7 of PWM, SCK of SPI2</td>
</tr>
</tbody>
</table>
## 2.3 Detailed Signal Descriptions

### 2.3.1 EXTAL, XTAL — Oscillator Pins

EXTAL and XTAL are the crystal driver and external clock pins. On reset all the device clocks are derived from the EXTAL input frequency. XTAL is the crystal output.
2.3.2 **RESET — External Reset Pin**

An active low bidirectional control signal, it acts as an input to initialize the MCU to a known start-up state, and an output when an internal MCU function causes a reset.

2.3.3 **TEST — Test Pin**

This input only pin is reserved for test.

*NOTE:* The TEST pin must be tied to VSS in all applications.

2.3.4 **VREGEN — Voltage Regulator Enable Pin**

This input only pin enables or disables the on-chip voltage regulator.

2.3.5 **XFC — PLL Loop Filter Pin**

PLL loop filter. Please ask your Motorola representative for the interactive application note to compute PLL loop filter elements. Any current leakage on this pin must be avoided.

![Figure 2-4 PLL Loop Filter Connections](image)

2.3.6 **BKGD / TAGHI / MODC — Background Debug, Tag High, and Mode Pin**

The BKGD/TAGHI/MODC pin is used as a pseudo-open-drain pin for the background debug communication. In MCU expanded modes of operation when instruction tagging is on, an input low on this pin during the falling edge of E-clock tags the high half of the instruction word being read into the instruction queue. It is used as a MCU operating mode select pin during reset. The state of this pin is latched to the MODC bit at the rising edge of RESET.

2.3.7 **PAD15 / AN15 / ETRIG1 — Port AD Input Pin of ATD1**

PAD15 is a general purpose input pin and analog input AN7 of the analog to digital converter ATD1. It can act as an external trigger input for the ATD1.
2.3.8 PAD[14:08] / AN[14:08] — Port AD Input Pins of ATD1

PAD14 - PAD08 are general purpose input pins and analog inputs AN[6:0] of the analog to digital converter ATD1.

2.3.9 PAD7 / AN07 / ETRIG0 — Port AD Input Pin of ATD0

PAD7 is a general purpose input pin and analog input AN7 of the analog to digital converter ATD0. It can act as an external trigger input for the ATD0.

2.3.10 PAD[06:00] / AN[06:00] — Port AD Input Pins of ATD0

PAD06 - PAD00 are general purpose input pins and analog inputs AN[6:0] of the analog to digital converter ATD0.


PA7-PA0 are general purpose input or output pins. In MCU expanded modes of operation, these pins are used for the multiplexed external address and data bus.

2.3.12 PB[7:0] / ADDR[7:0] / DATA[7:0] — Port B I/O Pins

PB7-PB0 are general purpose input or output pins. In MCU expanded modes of operation, these pins are used for the multiplexed external address and data bus.

2.3.13 PE7 / NOACC / XCLKS — Port E I/O Pin 7

PE7 is a general purpose input or output pin. During MCU expanded modes of operation, the NOACC signal, when enabled, is used to indicate that the current bus cycle is an unused or “free” cycle. This signal will assert when the CPU is not using the bus. The XCLKS input selects between an external clock or oscillator configuration. The state of this pin is latched at the rising edge of RESET. If the input is a logic low the EXTAL pin is configured for an external clock drive. If input is a logic high an oscillator circuit is configured on EXTAL and XTAL. Since this pin is an input with a pull-up device, if the pin is left floating, the default configuration is an oscillator circuit on EXTAL and XTAL.

2.3.14 PE6 / MODB / IPIPE1 — Port E I/O Pin 6

PE6 is a general purpose input or output pin. It is used as a MCU operating mode select pin during reset. The state of this pin is latched to the MODB bit at the rising edge of RESET. This pin is shared with the instruction queue tracking signal IPIPE1. This pin is an input with a pull-down device which is only active when RESET is low.
2.3.15 PE5 / MODA / IPIPE0 — Port E I/O Pin 5

PE5 is a general purpose input or output pin. It is used as a MCU operating mode select pin during reset. The state of this pin is latched to the MODA bit at the rising edge of RESET. This pin is shared with the instruction queue tracking signal IPIPE0. This pin is an input with a pull-down device which is only active when RESET is low.

2.3.16 PE4 / ECLK — Port E I/O Pin 4

PE4 is a general purpose input or output pin. It can be configured to drive the internal bus clock ECLK. ECLK can be used as a timing reference.

2.3.17 PE3 / LSTRB / TAGLO — Port E I/O Pin 3

PE3 is a general purpose input or output pin. In MCU expanded modes of operation, LSTRB can be used for the low-byte strobe function to indicate the type of bus access and when instruction tagging is on, TAGLO is used to tag the low half of the instruction word being read into the instruction queue.

2.3.18 PE2 / R/W — Port E I/O Pin 2

PE2 is a general purpose input or output pin. In MCU expanded modes of operations, this pin drives the read/write output signal for the external bus. It indicates the direction of data on the external bus.

2.3.19 PE1 / IRQ — Port E Input Pin 1

PE1 is a general purpose input pin and the maskable interrupt request input that provides a means of applying asynchronous interrupt requests. This will wake up the MCU from STOP or WAIT mode.

2.3.20 PE0 / XIRQ — Port E Input Pin 0

PE0 is a general purpose input pin and the non-maskable interrupt request input that provides a means of applying asynchronous interrupt requests. This will wake up the MCU from STOP or WAIT mode.

2.3.21 PH7 / KWH7 / SS2 — Port H I/O Pin 7

PH7 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as slave select pin SS of the Serial Peripheral Interface 2 (SPI2).

2.3.22 PH6 / KWH6 / SCK2 — Port H I/O Pin 6

PH6 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as serial clock pin SCK of the Serial Peripheral Interface 2 (SPI2).
2.3.23 PH5 / KWH5 / MOSI2 — Port H I/O Pin 5

PH5 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as master output (during master mode) or slave input pin (during slave mode) MOSI of the Serial Peripheral Interface 2 (SPI2).

2.3.24 PH4 / KWH4 / MISO2 — Port H I/O Pin 2

PH4 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as master input (during master mode) or slave output (during slave mode) pin MISO of the Serial Peripheral Interface 2 (SPI2).

2.3.25 PH3 / KWH3 / SS1 — Port H I/O Pin 3

PH3 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as slave select pin SS of the Serial Peripheral Interface 1 (SPI1).

2.3.26 PH2 / KWH2 / SCK1 — Port H I/O Pin 2

PH2 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as serial clock pin SCK of the Serial Peripheral Interface 1 (SPI1).

2.3.27 PH1 / KWH1 / MOSI1 — Port H I/O Pin 1

PH1 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as master output (during master mode) or slave input pin (during slave mode) MOSI of the Serial Peripheral Interface 1 (SPI1).

2.3.28 PH0 / KWH0 / MISO1 — Port H I/O Pin 0

PH0 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as master input (during master mode) or slave output (during slave mode) pin MISO of the Serial Peripheral Interface 1 (SPI1).

2.3.29 PJ7 / KWJ7 / TXCAN4 / SCL — PORT J I/O Pin 7

PJ7 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as the transmit pin TXCAN for the Motorola Scalable Controller Area Network controller 4 (CAN4) or the serial clock pin SCL of the IIC module.
2.3.30  PJ6 / KWJ6 / RXCAN4 / SDA — PORT J I/O Pin 6

PJ6 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as the receive pin RXCAN for the Motorola Scalable Controller Area Network controller 4 (CAN4) or the serial data pin SDA of the IIC module.

2.3.31  PJ[1:0] / KWJ[1:0] — Port J I/O Pins [1:0]

PJ1 and PJ0 are general purpose input or output pins. They can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode.

2.3.32  PK7 / ECS / ROMONE — Port K I/O Pin 7

PK7 is a general purpose input or output pin. During MCU expanded modes of operation, this pin is used as the emulation chip select output (ECS). During MCU normal expanded wide and narrow modes of operation, this pin is used to enable the Flash EEPROM memory in the memory map (ROMONE). At the rising edge of RESET, the state of this pin is latched to the ROMON bit.


PK5-PK0 are general purpose input or output pins. In MCU expanded modes of operation, these pins provide the expanded address XADDR[19:14] for the external bus.

2.3.34  PM7 / TXCAN3 / TXCAN4 — Port M I/O Pin 7

PM7 is a general purpose input or output pin. It can be configured as the transmit pin TXCAN of the Motorola Scalable Controller Area Network controllers 3 or 4 (CAN3 or CAN4).

2.3.35  PM6 / RXCAN3 / RXCAN4 — Port M I/O Pin 6

PM6 is a general purpose input or output pin. It can be configured as the receive pin RXCAN of the Motorola Scalable Controller Area Network controllers 3 or 4 (CAN3 or CAN4).

2.3.36  PM5 / TXCAN2 / TXCAN0 / TXCAN4 / SCK0 — Port M I/O Pin 5

PM5 is a general purpose input or output pin. It can be configured as the transmit pin TXCAN of the Motorola Scalable Controller Area Network controllers 2, 0 or 4 (CAN2, CAN0 or CAN4). It can be configured as the serial clock pin SCK of the Serial Peripheral Interface 0 (SPI0).

2.3.37  PM4 / RXCAN2 / RXCAN0 / RXCAN4/ MOSI0 — Port M I/O Pin 4

PM4 is a general purpose input or output pin. It can be configured as the receive pin RXCAN of the Motorola Scalable Controller Area Network controllers 2, 0 or 4 (CAN2, CAN0 or CAN4). It can be configured as the master output (during master mode) or slave input pin (during slave mode) MOSI for the Serial Peripheral Interface 0 (SPI0).
2.3.38 PM3 / TXCAN1 / TXCAN0 / SS0 — Port M I/O Pin 3

PM3 is a general purpose input or output pin. It can be configured as the transmit pin TXCAN of the Motorola Scalable Controller Area Network controllers 1 or 0 (CAN1 or CAN0). It can be configured as the slave select pin SS of the Serial Peripheral Interface 0 (SPI0).

2.3.39 PM2 / RXCAN1 / RXCAN0 / MISO0 — Port M I/O Pin 2

PM2 is a general purpose input or output pin. It can be configured as the receive pin RXCAN of the Motorola Scalable Controller Area Network controllers 1 or 0 (CAN1 or CAN0). It can be configured as the master input (during master mode) or slave output pin (during slave mode) MISO for the Serial Peripheral Interface 0 (SPI0).

2.3.40 PM1 / TXCAN0 / TXB — Port M I/O Pin 1

PM1 is a general purpose input or output pin. It can be configured as the transmit pin TXCAN of the Motorola Scalable Controller Area Network controller 0 (CAN0). It can be configured as the transmit pin TXB of the BDLC.

2.3.41 PM0 / RXCAN0 / RXB — Port M I/O Pin 0

PM0 is a general purpose input or output pin. It can be configured as the receive pin RXCAN of the Motorola Scalable Controller Area Network controller 0 (CAN0). It can be configured as the receive pin RXB of the BDLC.

2.3.42 PP7 / KWP7 / PWM7 / SCK2 — Port P I/O Pin 7

PP7 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 7 output. It can be configured as serial clock pin SCK of the Serial Peripheral Interface 2 (SPI2).

2.3.43 PP6 / KWP6 / PWM6 / SS2 — Port P I/O Pin 6

PP6 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 6 output. It can be configured as slave select pin SS of the Serial Peripheral Interface 2 (SPI2).

2.3.44 PP5 / KWP5 / PWM5 / MOSI2 — Port P I/O Pin 5

PP5 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 5 output. It can be configured as master output (during master mode) or slave input pin (during slave mode) MOSI of the Serial Peripheral Interface 2 (SPI2).
2.3.45 PP4 / KWP4 / PWM4 / MISO2 — Port P I/O Pin 4

PP4 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 4 output. It can be configured as master input (during master mode) or slave output (during slave mode) pin MISO of the Serial Peripheral Interface 2 (SPI2).

2.3.46 PP3 / KWP3 / PWM3 / SS1 — Port P I/O Pin 3

PP3 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 3 output. It can be configured as slave select pin SS of the Serial Peripheral Interface 1 (SPI1).

2.3.47 PP2 / KWP2 / PWM2 / SCK1 — Port P I/O Pin 2

PP2 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 2 output. It can be configured as serial clock pin SCK of the Serial Peripheral Interface 1 (SPI1).

2.3.48 PP1 / KWP1 / PWM1 / MOSI1 — Port P I/O Pin 1

PP1 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 1 output. It can be configured as master output (during master mode) or slave input pin (during slave mode) MOSI of the Serial Peripheral Interface 1 (SPI1).

2.3.49 PP0 / KWP0 / PWM0 / MISO1 — Port P I/O Pin 0

PP0 is a general purpose input or output pin. It can be configured to generate an interrupt causing the MCU to exit STOP or WAIT mode. It can be configured as Pulse Width Modulator (PWM) channel 0 output. It can be configured as master input (during master mode) or slave output (during slave mode) pin MISO of the Serial Peripheral Interface 1 (SPI1).

2.3.50 PS7 / SS0 — Port S I/O Pin 7

PS6 is a general purpose input or output pin. It can be configured as the slave select pin SS of the Serial Peripheral Interface 0 (SPI0).

2.3.51 PS6 / SCK0 — Port S I/O Pin 6

PS6 is a general purpose input or output pin. It can be configured as the serial clock pin SCK of the Serial Peripheral Interface 0 (SPI0).
2.3.52 PS5 / MOSI0 — Port S I/O Pin 5

PS5 is a general purpose input or output pin. It can be configured as master output (during master mode) or slave input pin (during slave mode) MOSI of the Serial Peripheral Interface 0 (SPI0).

2.3.53 PS4 / MISO0 — Port S I/O Pin 4

PS4 is a general purpose input or output pin. It can be configured as master input (during master mode) or slave output pin (during slave mode) MOSI of the Serial Peripheral Interface 0 (SPI0).

2.3.54 PS3 / TXD1 — Port S I/O Pin 3

PS3 is a general purpose input or output pin. It can be configured as the transmit pin TXD of Serial Communication Interface 1 (SCI1).

2.3.55 PS2 / RXD1 — Port S I/O Pin 2

PS2 is a general purpose input or output pin. It can be configured as the receive pin RXD of Serial Communication Interface 1 (SCI1).

2.3.56 PS1 / TXD0 — Port S I/O Pin 1

PS1 is a general purpose input or output pin. It can be configured as the transmit pin TXD of Serial Communication Interface 0 (SCI0).

2.3.57 PS0 / RXD0 — Port S I/O Pin 0

PS0 is a general purpose input or output pin. It can be configured as the receive pin RXD of Serial Communication Interface 0 (SCI0).

2.3.58 PT[7:0] / IOC[7:0] — Port T I/O Pins [7:0]

PT7-PT0 are general purpose input or output pins. They can be configured as input capture or output compare pins IOC7-IOC0 of the Enhanced Capture Timer (ECT).

2.4 Power Supply Pins

MC9S12DP256B power and ground pins are described below.

   NOTE: All VSS pins must be connected together in the application.
2.4.1 VDDX,VSSX — Power & Ground Pins for I/O Drivers

External power and ground for I/O drivers. Because fast signal transitions place high, short-duration current demands on the power supply, use bypass capacitors with high-frequency characteristics and place them as close to the MCU as possible. Bypass requirements depend on how heavily the MCU pins are loaded.

2.4.2 VDDR, VSSR — Power & Ground Pins for I/O Drivers & for Internal Voltage Regulator

External power and ground for I/O drivers and input to the internal voltage regulator. Because fast signal transitions place high, short-duration current demands on the power supply, use bypass capacitors with high-frequency characteristics and place them as close to the MCU as possible. Bypass requirements depend on how heavily the MCU pins are loaded.

2.4.3 VDD1, VDD2, VSS1, VSS2 — Core Power Pins

Power is supplied to the MCU through VDD and VSS. Because fast signal transitions place high, short-duration current demands on the power supply, use bypass capacitors with high-frequency characteristics and place them as close to the MCU as possible. This 2.5V supply is derived from the internal voltage regulator. There is no static load on those pins allowed. The internal voltage regulator is turned off, if VREGEN is tied to ground.

   **NOTE:** No load allowed except for bypass capacitors.

2.4.4 VDDA, VSSA — Power Supply Pins for ATD and VREG

VDDA, VSSA are the power supply and ground input pins for the voltage regulator and the analog to digital converter. It also provides the reference for the internal voltage regulator. This allows the supply voltage to the ATD and the reference voltage to be bypassed independently.

2.4.5 VRH, VRL — ATD Reference Voltage Input Pins

VRH and VRL are the reference voltage input pins for the analog to digital converter.

2.4.6 VDDPLL, VSSPLL — Power Supply Pins for PLL

Provides operating voltage and ground for the Oscillator and the Phased-Locked Loop. This allows the supply voltage to the Oscillator and PLL to be bypassed independently. This 2.5V voltage is generated by the internal voltage regulator.

   **NOTE:** No load allowed except for bypass capacitors.
Table 2-2  MC9S12DP256 Power and Ground Connection Summary

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Pin Number (112-pin QFP)</th>
<th>Nominal Voltage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD1,2</td>
<td>13, 65</td>
<td>2.5 V</td>
<td>Internal power and ground generated by internal regulator</td>
</tr>
<tr>
<td>VSS1,2</td>
<td>14, 66</td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>DDR</td>
<td>41</td>
<td>5.0 V</td>
<td>External power and ground, supply to pin drivers and internal voltage regulator.</td>
</tr>
<tr>
<td>SSR</td>
<td>40</td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>DDX</td>
<td>107</td>
<td>5.0 V</td>
<td>External power and ground, supply to pin drivers.</td>
</tr>
<tr>
<td>SSX</td>
<td>106</td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>DDA</td>
<td>83</td>
<td>5.0 V</td>
<td>Operating voltage and ground for the analog-to-digital converters and the reference for the internal voltage regulator, allows the supply voltage to the A/D to be bypassed independently.</td>
</tr>
<tr>
<td>SSA</td>
<td>86</td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>RL</td>
<td>85</td>
<td>0 V</td>
<td>Reference voltages for the analog-to-digital converter.</td>
</tr>
<tr>
<td>RH</td>
<td>84</td>
<td>5.0 V</td>
<td></td>
</tr>
<tr>
<td>DDPLL</td>
<td>43</td>
<td>2.5 V</td>
<td>Provides operating voltage and ground for the Phased-Locked Loop. This allows the supply voltage to the PLL to be bypassed independently. Internal power and ground generated by internal regulator.</td>
</tr>
<tr>
<td>SSPLL</td>
<td>45</td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>VREGEN</td>
<td>97</td>
<td>5V</td>
<td>Internal Voltage Regulator enable/disable</td>
</tr>
</tbody>
</table>

2.4.7  VREGEN — On Chip Voltage Regulator Enable

Enables the internal 5V to 2.5V voltage regulator. If this pin is tied low, VDD1,2 and VDDPLL must be supplied externally.
Section 3  System Clock Description

3.1 Overview

The Clock and Reset Generator provides the internal clock signals for the core and all peripheral modules. **Figure 3-1** shows the clock connections from the CRG to all modules.

Consult the CRG Block User Guide for details on clock generation.

![Figure 3-1 Clock Connections](image-url)
Section 4 Modes of Operation

4.1 Overview

Eight possible modes determine the operating configuration of the MC9S12DP256B. Each mode has an associated default memory map and external bus configuration controlled by a further pin.

Three low power modes exist for the device.

4.2 Chip Configuration Summary

The operating mode out of reset is determined by the states of the MODC, MODB, and MODA pins during reset (Table 4-1). The MODC, MODB, and MODA bits in the MODE register show the current operating mode and provide limited mode switching during operation. The states of the MODC, MODB, and MODA pins are latched into these bits on the rising edge of the reset signal. The ROMCTL signal allows the setting of the ROMON bit in the MISC register thus controlling whether the internal Flash is visible in the memory map. ROMON = 1 mean the Flash is visible in the memory map. The state of the ROMCTL pin is latched into the ROMON bit in the MISC register on the rising edge of the reset signal.

For further explanation on the modes refer to the Core User Guide.

<table>
<thead>
<tr>
<th>BKGD = MODC</th>
<th>PE6 = MODB</th>
<th>PE5 = MODA</th>
<th>PK7 = ROMCTL</th>
<th>ROMON Bit</th>
<th>Mode Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>1</td>
<td>Special Single Chip, BDM allowed and ACTIVE. BDM is allowed in all other modes but a serial command is required to make BDM active.</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>X</td>
<td>0</td>
<td>Emulation Expanded Narrow, BDM allowed</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>X</td>
<td>0</td>
<td>Special Test (Expanded Wide), BDM allowed</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>X</td>
<td>0</td>
<td>Emulation Expanded Wide, BDM allowed</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>1</td>
<td>Normal Single Chip, BDM allowed</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Normal Expanded Narrow, BDM allowed</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>X</td>
<td>1</td>
<td>Peripheral; BDM allowed but bus operations would cause bus conflicts (must not be used)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Normal Expanded Wide, BDM allowed</td>
</tr>
</tbody>
</table>

Table 4-2 Clock Selection Based on PE7

<table>
<thead>
<tr>
<th>PE7 = XCLKS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Colpitts Oscillator selected</td>
</tr>
<tr>
<td>0</td>
<td>External clock selected</td>
</tr>
</tbody>
</table>
The device will make available a security feature preventing the unauthorized read and write of the memory contents. This feature allows:

- Protection of the contents of FLASH,
- Protection of the contents of EEPROM,
- Operation in single-chip mode,
- Operation from external memory with internal FLASH and EEPROM disabled.

The user must be reminded that part of the security must lie with the user’s code. An extreme example would be user’s code that dumps the contents of the internal program. This code would defeat the purpose of security. At the same time the user may also wish to put a back door in the user’s program. An example of this is the user downloads a key through the SCI which allows access to a programming routine that updates parameters stored in EEPROM.

### 4.3.1 Securing the Microcontroller

Once the user has programmed the FLASH and EEPROM (if desired), the part can be secured by programming the security bits located in the FLASH module. These non-volatile bits will keep the part secured through resetting the part and through powering down the part.

The security byte resides in a portion of the Flash array.

Check the Flash Block User Guide for more details on the security configuration.

### 4.3.2 Operation of the Secured Microcontroller

#### 4.3.2.1 Normal Single Chip Mode

This will be the most common usage of the secured part. Everything will appear the same as if the part was not secured with the exception of BDM operation. The BDM operation will be blocked.

#### 4.3.2.2 Executing from External Memory

The user may wish to execute from external space with a secured microcontroller. This is accomplished by resetting directly into expanded mode. The internal FLASH and EEPROM will be disabled. BDM operations will be blocked.

<table>
<thead>
<tr>
<th>VREGEN</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Voltage Regulator enabled</td>
</tr>
<tr>
<td>0</td>
<td>Internal Voltage Regulator disabled, VDD1,2 and VDDPLL must be supplied externally with 2.5V</td>
</tr>
</tbody>
</table>
4.3.3 Unsecuring the Microcontroller

In order to unsecure the microcontroller, the internal FLASH and EEPROM must be erased. This can be done through an external program in expanded mode.

Once the user has erased the FLASH and EEPROM, the part can be reset into special single chip mode. This invokes a program that verifies the erasure of the internal FLASH and EEPROM. Once this program completes, the user can erase and program the FLASH security bits to the unsecured state. This is generally done through the BDM, but the user could also change to expanded mode (by writing the mode bits through the BDM) and jumping to an external program (again through BDM commands). Note that if the part goes through a reset before the security bits are reprogrammed to the unsecure state, the part will be secured again.

4.4 Low Power Modes

The microcontroller features three main low power modes. Consult the respective Block User Guide for information on the module behavior in Stop, Pseudo Stop, and Wait Mode. An important source of information about the clock system is the Clock and Reset Generator User Guide (CRG).

4.4.1 Stop

Executing the CPU STOP instruction stops all clocks and the oscillator thus putting the chip in fully static mode. Wake up from this mode can be done via reset or external interrupts.

4.4.2 Pseudo Stop

This mode is entered by executing the CPU STOP instruction. In this mode the oscillator is still running and the Real Time Interrupt (RTI) or Watchdog (COP) sub module can stay active. Other peripherals are turned off. This mode consumes more current than the full STOP mode, but the wake up time from this mode is significantly shorter.

4.4.3 Wait

This mode is entered by executing the CPU WAI instruction. In this mode the CPU will not execute instructions. The internal CPU signals (address and databus) will be fully static. All peripherals stay active. For further power consumption the peripherals can individually turn off their local clocks.

4.4.4 Run

Although this is not a low power mode, unused peripheral modules should not be enabled in order to save power.
Section 5  Resets and Interrupts

5.1 Overview

Consult the Exception Processing section of the HCS12 Core User Guide for information on resets and interrupts.

5.2 Vectors

5.2.1 Vector Table

Table 5-1 lists interrupt sources and vectors in default order of priority.

<table>
<thead>
<tr>
<th>Vector Address</th>
<th>Interrupt Source</th>
<th>CCR Mask</th>
<th>Local Enable</th>
<th>HPRIO Value to Elevate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$FFFFE, $FFFFF</td>
<td>Reset</td>
<td>None</td>
<td>None</td>
<td>–</td>
</tr>
<tr>
<td>$FFFC, $FFFD</td>
<td>Clock Monitor fail reset</td>
<td>None</td>
<td>PLLCTL (CME, SCME)</td>
<td>–</td>
</tr>
<tr>
<td>$FFFA, $FFFB</td>
<td>COP failure reset</td>
<td>None</td>
<td>COP rate select</td>
<td>–</td>
</tr>
<tr>
<td>$FFFA, $FFFB</td>
<td>Unimplemented instruction trap</td>
<td>None</td>
<td>None</td>
<td>–</td>
</tr>
<tr>
<td>$FFFE, $FFFD</td>
<td>SWI</td>
<td>None</td>
<td>None</td>
<td>–</td>
</tr>
<tr>
<td>$FFFF, $FFFF</td>
<td>XIRQ</td>
<td>X-Bit</td>
<td>None</td>
<td>–</td>
</tr>
<tr>
<td>$FFFF2, $FFFF3</td>
<td>IRQ</td>
<td>I-Bit</td>
<td>IRQCR (IRQEN)</td>
<td>$F2</td>
</tr>
<tr>
<td>$FFFF0, $FFFF1</td>
<td>Real Time Interrupt</td>
<td>I-Bit</td>
<td>CRGINT (RTIE)</td>
<td>$F0</td>
</tr>
<tr>
<td>$FFEE, $FFEF</td>
<td>Enhanced Capture Timer channel 0</td>
<td>I-Bit</td>
<td>TIE (C0I)</td>
<td>$EE</td>
</tr>
<tr>
<td>$FFEC, $FFED</td>
<td>Enhanced Capture Timer channel 1</td>
<td>I-Bit</td>
<td>TIE (C1I)</td>
<td>$EC</td>
</tr>
<tr>
<td>$FFEA, $FFEB</td>
<td>Enhanced Capture Timer channel 2</td>
<td>I-Bit</td>
<td>TIE (C2I)</td>
<td>$EA</td>
</tr>
<tr>
<td>$FFE8, $FFE9</td>
<td>Enhanced Capture Timer channel 3</td>
<td>I-Bit</td>
<td>TIE (C3I)</td>
<td>$E8</td>
</tr>
<tr>
<td>$FFE6, $FFE7</td>
<td>Enhanced Capture Timer channel 4</td>
<td>I-Bit</td>
<td>TIE (C4I)</td>
<td>$E6</td>
</tr>
<tr>
<td>$FFE4, $FFE5</td>
<td>Enhanced Capture Timer channel 5</td>
<td>I-Bit</td>
<td>TIE (C5I)</td>
<td>$E4</td>
</tr>
<tr>
<td>$FFE2, $FFE3</td>
<td>Enhanced Capture Timer channel 6</td>
<td>I-Bit</td>
<td>TIE (C6I)</td>
<td>$E2</td>
</tr>
<tr>
<td>$FFE0, $FFE1</td>
<td>Enhanced Capture Timer channel 7</td>
<td>I-Bit</td>
<td>TIE (C7I)</td>
<td>$E0</td>
</tr>
<tr>
<td>$FFDE, $FFDF</td>
<td>Enhanced Capture Timer overflow</td>
<td>I-Bit</td>
<td>TSR2 (TOF)</td>
<td>$DE</td>
</tr>
<tr>
<td>$FFDC, $FFDD</td>
<td>Pulse accumulator A overflow</td>
<td>I-Bit</td>
<td>PACTL (PAOVI)</td>
<td>$DC</td>
</tr>
<tr>
<td>$FFDA, $FFDB</td>
<td>Pulse accumulator input edge</td>
<td>I-Bit</td>
<td>PACTL (PAI)</td>
<td>$DA</td>
</tr>
<tr>
<td>$FFD8, $FFD9</td>
<td>SPI0</td>
<td>I-Bit</td>
<td>SP0CR1 (SPIE, SPTIE)</td>
<td>$D8</td>
</tr>
<tr>
<td>$FFD6, $FFD7</td>
<td>SCI0</td>
<td>I-Bit</td>
<td>SCOCR2 (TIE, TCIE, RIE, ILIE)</td>
<td>$D6</td>
</tr>
<tr>
<td>$FFD4, $FFD5</td>
<td>SCI1</td>
<td>I-Bit</td>
<td>SCOCR2 (TIE, TCIE, RIE, ILIE)</td>
<td>$D4</td>
</tr>
<tr>
<td>$FFD2, $FFD3</td>
<td>ATD0</td>
<td>I-Bit</td>
<td>ATD0CTL2 (ASCIE)</td>
<td>$D2</td>
</tr>
<tr>
<td>$FFD0, $FFD1</td>
<td>ATD1</td>
<td>I-Bit</td>
<td>ATD1CTL2 (ASCIE)</td>
<td>$D0</td>
</tr>
<tr>
<td>$FFCE, $FFCF</td>
<td>Port J</td>
<td>I-Bit</td>
<td>PTJIF (PTJIE)</td>
<td>$CE</td>
</tr>
<tr>
<td>$FFCC, $FFCD</td>
<td>Port H</td>
<td>I-Bit</td>
<td>PTHIF (PTHIE)</td>
<td>$CC</td>
</tr>
<tr>
<td>$FFCA, $FFCB</td>
<td>Modulus Down Counter underflow</td>
<td>I-Bit</td>
<td>MCCTL(MCZI)</td>
<td>$CA</td>
</tr>
</tbody>
</table>
5.3 Effects of Reset

When a reset occurs, MCU registers and control bits are changed to known start-up states. Refer to the respective module Block User Guides for register reset states.

5.3.1 I/O pins

Refer to the HCS12 Core User Guides for mode dependent pin configuration of port A, B, E and K out of reset.

Refer to the PIM Block User Guide for reset configurations of all peripheral module ports.
NOTE: For devices assembled in 80-pin QFP packages all non-bonded out pins should be configured as outputs after reset in order to avoid current drawn from floating inputs. Refer to Table 2-1 for affected pins.

5.3.2 Memory

Refer to Table 1-1 for locations of the memories depending on the operating mode after reset.

The RAM array is not automatically initialized out of reset.
Section 6  HCS12 Core Block Description

Consult the HCS12 Core User Guide for information about the HCS12 core modules, i.e. central processing unit (CPU), interrupt module (INT), module mapping control module (MMC), multiplexed external bus interface (MEBI), breakpoint module (BKP) and background debug mode module (BDM).

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>MC9S12DP256B Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUCR_RESET</td>
<td>PUCR reset state</td>
<td>$90</td>
</tr>
<tr>
<td>NUM_INT</td>
<td>Interrupt Request Bus Width</td>
<td>56</td>
</tr>
<tr>
<td>INITEE_RST</td>
<td>INITEE reset state</td>
<td>$01</td>
</tr>
<tr>
<td>INITEE_WOK</td>
<td>INITEE Write anytime in normal mode</td>
<td>INITEE register is writeable once in normal modes</td>
</tr>
<tr>
<td>PPAGE_SMOD_ONLY</td>
<td>PPAGE Write only in special mode</td>
<td>PPAGE register is writable in all modes, reset state of the PPAGE register is $00</td>
</tr>
</tbody>
</table>

Section 7  Clock and Reset Generator (CRG) Block Description

Consult the CRG Block User Guide for information about the Clock and Reset Generator module.

7.1  Device-specific information

7.1.1  XCLKS

The XCLKS input signal is active low (see 2.3.13 PE7 / NOACC / XCLKS — Port E I/O Pin 7).

Section 8  Enhanced Capture Timer (ECT) Block Description

Consult the ECT_16B8C Block User Guide for information about the Enhanced Capture Timer module.

Section 9  Analog to Digital Converter (ATD) Block Description

There are two Analog to Digital Converters (ATD1 and ATD0) implemented on the MC9S12DP256B. Consult the ATD_10B8C Block User Guide for information about each Analog to Digital Converter module.
Section 10 Inter-IC Bus (IIC) Block Description

Consult the IIC Block User Guide for information about the Inter-IC Bus module.

Section 11 Serial Communications Interface (SCI) Block Description

There are two Serial Communications Interfaces (SCI1 and SCI0) implemented on the MC9S12DP256B device. Consult the SCI Block User Guide for information about each Serial Communications Interface module.

Section 12 Serial Peripheral Interface (SPI) Block Description

There are three Serial Peripheral Interfaces(SPI2, SPI1 and SPI0) implemented on MC9S12DP256B. Consult the SPI Block User Guide for information about each Serial Peripheral Interface module.

Section 13 J1850 (BDLC) Block Description

Consult the BDLC Block User Guide for information about the J1850 module.

Section 14 Pulse Width Modulator (PWM) Block Description

Consult the PWM_8B8C Block User Guide for information about the Pulse Width Modulator module.

Section 15 Flash EEPROM 256K Block Description

Consult the FTS256K Block User Guide for information about the flash module.

Section 16 EEPROM 4K Block Description

Consult the EETS4K Block User Guide for information about the EEPROM module.

Section 17 RAM Block Description
This module supports single-cycle misaligned word accesses.

**Section 18  MSCAN Block Description**

There are five MSCAN modules (CAN4, CAN3, CAN2, CAN1 and CAN0) implemented on the MC9S12DP256B. Consult the MSCAN Block User Guide for information about the Motorola Scalable CAN Module.

**Section 19  Port Integration Module (PIM) Block Description**

Consult the PIM_9DP256 Block User Guide for information about the Port Integration Module.

**Section 20  Voltage Regulator (VREG) Block Description**

Consult the VREG Block User Guide for information about the dual output linear voltage regulator.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>VDD1 filter cap</td>
<td>ceramic X7R</td>
<td>100 .. 220nF</td>
</tr>
<tr>
<td>C2</td>
<td>VDD2 filter cap</td>
<td>ceramic X7R</td>
<td>100 .. 220nF</td>
</tr>
<tr>
<td>C3</td>
<td>VDDA filter cap</td>
<td>ceramic X7R</td>
<td>100nF</td>
</tr>
<tr>
<td>C4</td>
<td>VDDR filter cap</td>
<td>X7R/tantalum</td>
<td>&gt;=100nF</td>
</tr>
<tr>
<td>C5</td>
<td>VDDPLL filter cap</td>
<td>ceramic X7R</td>
<td>100nF</td>
</tr>
<tr>
<td>C6</td>
<td>VDDX filter cap</td>
<td>X7R/tantalum</td>
<td>&gt;=100nF</td>
</tr>
<tr>
<td>C7</td>
<td>OSC load cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C8</td>
<td>OSC load cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C9</td>
<td>PLL loop filter cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C10</td>
<td>PLL loop filter cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C11</td>
<td>DC cutoff cap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>PLL loop filter res</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>Quartz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The PCB must be carefully laid out to ensure proper operation of the voltage regulator as well as of the MCU itself. The following rules must be observed:
Every supply pair must be decoupled by a ceramic capacitor connected as near as possible to the corresponding pins (C1 - C6).

Central point of the ground star should be the VSSR pin.

Use low ohmic low inductance connections between VSS1, VSS2 and VSSR.

VSSPLL must be directly connected to VSSR.

Keep traces of VSSPLL, EXTAL and XTAL as short as possible and occupied board area for C7, C8, C11 and Q1 as small as possible.

Do not place other signals or supplies underneath area occupied by C7, C8, C10 and Q1 and the connection area to the MCU.

Central power input should be fed in at the VDDA/VSSA pins.
Figure 20-1 Recommended PCB Layout 112 LQFP
Figure 20-2  Recommended PCB Layout for 80QFP
Appendix A  Electrical Characteristics

A.1 General

NOTE:  The electrical characteristics given in this section are preliminary and should be used as a guide only. Values cannot be guaranteed by Motorola and are subject to change without notice.

This supplement contains the most accurate electrical information for the MC9S12DP256B microcontroller available at the time of publication. The information should be considered PRELIMINARY and is subject to change.

This introduction is intended to give an overview on several common topics like power supply, current injection etc.

A.1.1 Parameter Classification

The electrical parameters shown in this supplement are guaranteed by various methods. To give the customer a better understanding the following classification is used and the parameters are tagged accordingly in the tables where appropriate.

NOTE:  This classification is shown in the column labeled “C” in the parameter tables where appropriate.

P:
Those parameters are guaranteed during production testing on each individual device.

C:
Those parameters are achieved by the design characterization by measuring a statistically relevant sample size across process variations.

T:
Those parameters are achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted. All values shown in the typical column are within this category.

D:
Those parameters are derived mainly from simulations.

A.1.2 Power Supply

The MC9S12DP256B utilizes several pins to supply power to the I/O ports, A/D converter, oscillator and PLL as well as the digital core.

The VDDA, VSSA pair supplies the A/D converter and the resistor ladder of the internal voltage regulator.
The VDDX, VSSX, VDDR and VSSR pairs supply the I/O pins, VDDR supplies also the internal voltage regulator.

VDD1, VSS1, VDD2 and VSS2 are the supply pins for the digital logic, VDDPLL, VSSPLL supply the oscillator and the PLL.

VSS1 and VSS2 are internally connected by metal.

VDDA, VDDX, VDDR as well as VSSA, VSSX, VSSR are connected by anti-parallel diodes for ESD protection.

**NOTE:** In the following context VDD5 is used for either VDDA, VDDR and VDDX; VSS5 is used for either VSSA, VSSR and VSSX unless otherwise noted.

IDD5 denotes the sum of the currents flowing into the VDDA, VDDX and VDDR pins.

VDD is used for VDD1, VDD2 and VDDPLL, VSS is used for VSS1, VSS2 and VSSPLL.

IDD is used for the sum of the currents flowing into VDD1 and VDD2.

**A.1.3 Pins**

There are four groups of functional pins.

**A.1.3.1 5V I/O pins**

Those I/O pins have a nominal level of 5V. This class of pins is comprised of all port I/O pins, the analog inputs, BKGD and the RESET pins. The internal structure of all those pins is identical, however some of the functionality may be disabled. E.g. for the analog inputs the output drivers, pull-up and pull-down resistors are disabled permanently.

**A.1.3.2 Analog Reference**

This group is made up by the VRH and VRL pins.

**A.1.3.3 Oscillator**

The pins XFC, EXTAL, XTAL dedicated to the oscillator have a nominal 2.5V level. They are supplied by VDDPLL.

**A.1.3.4 TEST**

This pin is used for production testing only.

**A.1.3.5 VREGEN**

This pin is used to enable the on chip voltage regulator.
A.1.4 Current Injection

Power supply must maintain regulation within operating V_{DD5} or V_{DD} range during instantaneous and operating maximum current conditions. If positive injection current (V_{in} > V_{DD5}) is greater than I_{DD5}, the injection current may flow out of VDD5 and could result in external power supply going out of regulation. Ensure external VDD5 load will shunt current greater than maximum injection current. This will be the greatest risk when the MCU is not consuming power; e.g. if no system clock is present, or if clock rate is very low which would reduce overall power consumption.

A.1.5 Absolute Maximum Ratings

Absolute maximum ratings are stress ratings only. A functional operation under or outside those maxima is not guaranteed. Stress beyond those limits may affect the reliability or cause permanent damage of the device.

This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, it is advised that normal precautions be taken to avoid application of any voltages higher than maximum-rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (e.g., either V_{SS5} or V_{DD5}).

<table>
<thead>
<tr>
<th>Num</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I/O, Regulator and Analog Supply Voltage</td>
<td>V_{DD5}</td>
<td>-0.3</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>Digital Logic Supply Voltage</td>
<td>V_{DD}</td>
<td>-0.3</td>
<td>3.0</td>
<td>V</td>
</tr>
<tr>
<td>3</td>
<td>PLL Supply Voltage</td>
<td>V_{DDPLL}</td>
<td>-0.3</td>
<td>3.0</td>
<td>V</td>
</tr>
<tr>
<td>4</td>
<td>Voltage difference VDDX to VDDR and VDDA</td>
<td>Δ_{VDDX}</td>
<td>-0.3</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>5</td>
<td>Voltage difference VSSX to VSSR and VSSA</td>
<td>Δ_{VSSX}</td>
<td>-0.3</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td>6</td>
<td>Digital I/O Input Voltage</td>
<td>V_{IN}</td>
<td>-0.3</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>7</td>
<td>Analog Reference</td>
<td>V_{RH, RL}</td>
<td>-0.3</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>8</td>
<td>XFC, EXTL, XTAL inputs</td>
<td>V_{ILV}</td>
<td>-0.3</td>
<td>3.0</td>
<td>V</td>
</tr>
<tr>
<td>9</td>
<td>TEST input</td>
<td>V_{TEST}</td>
<td>-0.3</td>
<td>10.0</td>
<td>V</td>
</tr>
<tr>
<td>10</td>
<td>Instantaneous Maximum Current</td>
<td>I_{D}</td>
<td>-25</td>
<td>+25</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Single pin limit for all digital I/O pins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Num</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Instantaneous Maximum Current</td>
<td>I_{DL}</td>
<td>-25</td>
<td>+25</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Single pin limit for XFC, EXTL, XTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Instantaneous Maximum Current</td>
<td>I_{DT}</td>
<td>-0.25</td>
<td>0</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Single pin limit for TEST</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Storage Temperature Range</td>
<td>T_{stg}</td>
<td>-65</td>
<td>155</td>
<td>°C</td>
</tr>
</tbody>
</table>

NOTES:
1. Beyond absolute maximum ratings device might be damaged.
A.1.6 ESD Protection and Latch-up Immunity

All ESD testing is in conformity with CDF-AEC-Q100 Stress test qualification for Automotive Grade Integrated Circuits. During the device qualification ESD stresses were performed for the Human Body Model (HBM), the Machine Model (MM) and the Charge Device Model.

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

### Table A-2  ESD and Latch-up Test Conditions

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Body</td>
<td>Series Resistance</td>
<td>R1</td>
<td>1500</td>
<td>Ohm</td>
</tr>
<tr>
<td></td>
<td>Storage Capacitance</td>
<td>C</td>
<td>100</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td>Number of Pulse per pin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>positive</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Machine</td>
<td>Series Resistance</td>
<td>R1</td>
<td>0</td>
<td>Ohm</td>
</tr>
<tr>
<td></td>
<td>Storage Capacitance</td>
<td>C</td>
<td>200</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td>Number of Pulse per pin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>positive</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>negative</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Latch-up</td>
<td>Minimum input voltage limit</td>
<td></td>
<td>-2.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Maximum input voltage limit</td>
<td></td>
<td>7.5</td>
<td>V</td>
</tr>
</tbody>
</table>

### Table A-3  ESD and Latch-Up Protection Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>Human Body Model (HBM)</td>
<td>V_{HBM}</td>
<td>2000</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>Machine Model (MM)</td>
<td>V_{MM}</td>
<td>200</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Charge Device Model (CDM)</td>
<td>V_{CDM}</td>
<td>500</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>Latch-up Current at ( T_A = 125^\circ C ) positive negative</td>
<td>I_{LAT}</td>
<td>+100</td>
<td>-100</td>
<td>mA</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>Latch-up Current at ( T_A = 27^\circ C ) positive negative</td>
<td>I_{LAT}</td>
<td>+200</td>
<td>-200</td>
<td>mA</td>
</tr>
</tbody>
</table>
A.1.7 Operating Conditions

This chapter describes the operating conditions of the device. Unless otherwise noted those conditions apply to all the following data.

**NOTE:** Please refer to the temperature rating of the device (C, V, M) with regards to the ambient temperature \( T_A \) and the junction temperature \( T_J \). For power dissipation calculations refer to Section A.1.8 Power Dissipation and Thermal Characteristics.

### Table A-4 Operating Conditions

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O, Regulator and Analog Supply Voltage</td>
<td>( V_{DD5} )</td>
<td>4.5</td>
<td>5</td>
<td>5.25</td>
<td>V</td>
</tr>
<tr>
<td>Digital Logic Supply Voltage (^1)</td>
<td>( V_{DD} )</td>
<td>2.35</td>
<td>2.5</td>
<td>2.75</td>
<td>V</td>
</tr>
<tr>
<td>PLL Supply Voltage (^2)</td>
<td>( V_{DDPLL} )</td>
<td>2.35</td>
<td>2.5</td>
<td>2.75</td>
<td>V</td>
</tr>
<tr>
<td>Voltage Difference VDDX to VDDR and VDDA</td>
<td>( \Delta V_{DDX} )</td>
<td>-0.1</td>
<td>0</td>
<td>0.1</td>
<td>V</td>
</tr>
<tr>
<td>Voltage Difference VSSX to VSSR and VSSA</td>
<td>( \Delta V_{SSX} )</td>
<td>-0.1</td>
<td>0</td>
<td>0.1</td>
<td>V</td>
</tr>
<tr>
<td>Oscillator</td>
<td>( f_{osc} )</td>
<td>0.5</td>
<td>-</td>
<td>16</td>
<td>MHz</td>
</tr>
<tr>
<td>Bus Frequency</td>
<td>( f_{bus} )</td>
<td>0.5</td>
<td>-</td>
<td>25</td>
<td>MHz</td>
</tr>
<tr>
<td>MC9S12DP256BC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Junction Temperature Range</td>
<td>( T_J )</td>
<td>-40</td>
<td>-</td>
<td>100</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Ambient Temperature Range (^2)</td>
<td>( T_A )</td>
<td>-40</td>
<td>27</td>
<td>85</td>
<td>°C</td>
</tr>
<tr>
<td>MC9S12DP256BV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Junction Temperature Range</td>
<td>( T_J )</td>
<td>-40</td>
<td>-</td>
<td>120</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Ambient Temperature Range (^2)</td>
<td>( T_A )</td>
<td>-40</td>
<td>27</td>
<td>105</td>
<td>°C</td>
</tr>
<tr>
<td>MC9S12DP256BM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Junction Temperature Range</td>
<td>( T_J )</td>
<td>-40</td>
<td>-</td>
<td>140</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Ambient Temperature Range (^2)</td>
<td>( T_A )</td>
<td>-40</td>
<td>27</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

**NOTES:**
1. The device contains an internal voltage regulator to generate the logic and PLL supply out of the I/O supply. The absolute maximum ratings apply when this regulator is disabled and the device is powered from an external source.
2. Please refer to Section A.1.8 Power Dissipation and Thermal Characteristics for more details about the relation between ambient temperature \( T_A \) and device junction temperature \( T_J \).

A.1.8 Power Dissipation and Thermal Characteristics

Power dissipation and thermal characteristics are closely related. The user must assure that the maximum operating junction temperature is not exceeded. The average chip-junction temperature (\( T_J \)) in °C can be obtained from:
The total power dissipation can be calculated from:

\[ P_D = P_{INT} + P_{IO} \]

\[ P_{INT} = \text{Chip Internal Power Dissipation, [W]} \]

Two cases with internal voltage regulator enabled and disabled must be considered:

1. Internal Voltage Regulator disabled

\[ P_{INT} = I_{DD} \cdot V_{DD} + I_{DDPLL} \cdot V_{DDPLL} + I_{DDA} \cdot V_{DDA} \]

\[ P_{IO} = \sum R_{DSON} \cdot I_{IO_i}^2 \]

\( P_{IO} \) is the sum of all output currents on I/O ports associated with VDDX and VDDR.

For \( R_{DSON} \) is valid:

\[ R_{DSON} = \frac{V_{OL}}{I_{OL}} \text{: for outputs driven low} \]

respectively

\[ R_{DSON} = \frac{V_{DD5} - V_{OH}}{I_{OH}} \text{: for outputs driven high} \]

2. Internal voltage regulator enabled

\[ P_{INT} = I_{DDR} \cdot V_{DDR} + I_{DDA} \cdot V_{DDA} \]

\( I_{DDR} \) is the current shown in Table A-7 and not the overall current flowing into VDDR, which additionally contains the current flowing into the external loads with output high.

\[ P_{IO} = \sum R_{DSON} \cdot I_{IO_i}^2 \]

\( P_{IO} \) is the sum of all output currents on I/O ports associated with VDDX and VDDR.
### Table A-5  Thermal Package Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T</td>
<td>Thermal Resistance LQFP112, single sided PCB</td>
<td>$\theta_{JA}$</td>
<td>-</td>
<td>-</td>
<td>54</td>
<td>°C/W</td>
</tr>
<tr>
<td>2</td>
<td>T</td>
<td>Thermal Resistance LQFP112, double sided PCB with 2 internal planes</td>
<td>$\theta_{JA}$</td>
<td>-</td>
<td>-</td>
<td>41</td>
<td>°C/W</td>
</tr>
<tr>
<td>3</td>
<td>T</td>
<td>Thermal Resistance LQFP 80, single sided PCB</td>
<td>$\theta_{JA}$</td>
<td>-</td>
<td>-</td>
<td>51</td>
<td>°C/W</td>
</tr>
<tr>
<td>4</td>
<td>T</td>
<td>Thermal Resistance LQFP 80, double sided PCB with 2 internal planes</td>
<td>$\theta_{JA}$</td>
<td>-</td>
<td>-</td>
<td>41</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

NOTES:
1. The values for thermal resistance are achieved by package simulations
2. PC Board according to EIA/JEDEC Standard 51-2
3. PC Board according to EIA/JEDEC Standard 51-7

### A.1.9 I/O Characteristics

This section describes the characteristics of all 5V I/O pins. All parameters are not always applicable, e.g. not all pins feature pull up/down resistances.
## Table A-6 5V I/O Characteristics

Conditions are shown in Table A-4 unless otherwise noted.

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Input High Voltage</td>
<td>$V_{IH}$</td>
<td>0.65*V_{DD5}</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>Input High Voltage</td>
<td>$V_{IH}$</td>
<td>-</td>
<td>-</td>
<td>VDD5 + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>Input Low Voltage</td>
<td>$V_{IL}$</td>
<td>-</td>
<td>-</td>
<td>0.35*V_{DD5}</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>Input Low Voltage</td>
<td>$V_{IL}$</td>
<td>VSS5 - 0.3</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Input Hysteresis</td>
<td>$V_{HYS}$</td>
<td>250</td>
<td>-</td>
<td>-</td>
<td>mV</td>
</tr>
<tr>
<td>4</td>
<td>P</td>
<td>Input Leakage Current (pins in high impedance input mode)(^1)</td>
<td>$I_{in}$</td>
<td>-2.5</td>
<td>-</td>
<td>2.5</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{in} = V_{DD5}$ or $V_{SS5}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>P</td>
<td>Output High Voltage (pins in output mode)</td>
<td>$V_{OH}$</td>
<td>V_{DD5} - 0.8</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial Drive $I_{OH} = -2mA$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full Drive $I_{OH} = -10mA$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>P</td>
<td>Output Low Voltage (pins in output mode)</td>
<td>$V_{OL}$</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Partial Drive $I_{OL} = +2mA$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full Drive $I_{OL} = +10mA$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>Internal Pull Up Device Current, tested at $V_{IL}$ Max.</td>
<td>$I_{PUL}$</td>
<td>-</td>
<td>-</td>
<td>-130</td>
<td>μA</td>
</tr>
<tr>
<td>8</td>
<td>P</td>
<td>Internal Pull Up Device Current, tested at $V_{IH}$ Min.</td>
<td>$I_{PUH}$</td>
<td>-10</td>
<td>-</td>
<td>-</td>
<td>μA</td>
</tr>
<tr>
<td>9</td>
<td>P</td>
<td>Internal Pull Down Device Current, tested at $V_{IH}$ Min.</td>
<td>$I_{PDH}$</td>
<td>-</td>
<td>-</td>
<td>130</td>
<td>μA</td>
</tr>
<tr>
<td>10</td>
<td>P</td>
<td>Internal Pull Down Device Current, tested at $V_{IL}$ Max.</td>
<td>$I_{PDL}$</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>μA</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Input Capacitance</td>
<td>$C_{in}$</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>pF</td>
</tr>
<tr>
<td>12</td>
<td>T</td>
<td>Injection current(^2) Single Pin limit</td>
<td>$I_{ICS}$</td>
<td>-2.5</td>
<td>-</td>
<td>2.5</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Device Limit. Sum of all injected currents</td>
<td>$I_{ICP}$</td>
<td>-25</td>
<td>-</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>P</td>
<td>Port H, J, P Interrupt Input Pulse filtered(^3)</td>
<td>$I_{PULSE}$</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>μs</td>
</tr>
<tr>
<td>14</td>
<td>P</td>
<td>Port H, J, P Interrupt Input Pulse passed(^3)</td>
<td>$I_{PULSE}$</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>μs</td>
</tr>
</tbody>
</table>

### NOTES:

1. Maximum leakage current occurs at maximum operating temperature. Current decreases by approximately one-half for each 8°C to 12°C in the temperature range from 50°C to 125°C.
2. Refer to Section A.1.4 Current Injection, for more details.
3. Parameter only applies in STOP or Pseudo STOP mode.
A.1.10 Supply Currents

This section describes the current consumption characteristics of the device as well as the conditions for the measurements.

A.1.10.1 Measurement Conditions

All measurements are without output loads. Unless otherwise noted the currents are measured in single chip mode, internal voltage regulator enabled and at 25MHz bus frequency using a 4MHz oscillator in Colpitts mode. Production testing is performed using a square wave signal at the EXTAL input.

A.1.10.2 Additional Remarks

In expanded modes the currents flowing in the system are highly dependent on the load at the address, data and control signals as well as on the duty cycle of those signals. No generally applicable numbers can be
given. A very good estimate is to take the single chip currents and add the currents due to the external loads.

### Table A-7 Supply Current Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Run supply currents</td>
<td>$I_{DDS}$</td>
<td>65</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single Chip, Internal regulator enabled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>Wait Supply current</td>
<td>$I_{DDW}$</td>
<td>40</td>
<td>5</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All modules enabled, PLL on only RTI enabled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>Pseudo Stop Current (RTI and COP disabled)</td>
<td>$I_{DDPS}$</td>
<td>370</td>
<td>400</td>
<td>500</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-40°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;C&quot; Temp Option 100°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>105°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;V&quot; Temp Option 120°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;M&quot; Temp Option 140°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Pseudo Stop Current (RTI and COP enabled)</td>
<td>$I_{DDPS}$</td>
<td>970</td>
<td>600</td>
<td>1600</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-40°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>85°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>105°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>140°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>Pseudo Stop Current (RTI and COP enabled)</td>
<td>$I_{DDPS}$</td>
<td>970</td>
<td>600</td>
<td>1600</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-40°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>105°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>140°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>Stop Current</td>
<td>$I_{DDS}$</td>
<td>12</td>
<td>25</td>
<td>100</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-40°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27°C</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;C&quot; Temp Option 100°C</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
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<td>105°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;V&quot; Temp Option 120°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;M&quot; Temp Option 140°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. PLL off
2. At those low power dissipation levels $T_J = T_A$ can be assumed
A.2 ATD Characteristics

This section describes the characteristics of the analog to digital converter.

A.2.1 ATD Operating Characteristics

The Table A-8 shows conditions under which the ATD operates.

The following constraints exist to obtain full-scale, full range results:
\[ V_{SSA} \leq V_{RL} \leq V_{IN} \leq V_{RH} \leq V_{DDA} \]. This constraint exists since the sample buffer amplifier can not drive beyond the power supply levels that it ties to. If the input level goes outside of this range it will effectively be clipped.

### Table A-8 ATD Operating Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D</td>
<td>Reference Potential</td>
<td>Low, High</td>
<td>( V_{RL} ), ( V_{RH} )</td>
<td>( V_{SSA} ), ( V_{DDA}/2 )</td>
<td>( V_{DDA}/2 ), ( V_{DDA} )</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>Differential Reference Voltage(^1)</td>
<td></td>
<td>4.50</td>
<td>5.00</td>
<td>5.25</td>
<td>V</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>ATD Clock Frequency</td>
<td>( f_{ATDCCLK} )</td>
<td>0.5</td>
<td></td>
<td>2.0</td>
<td>MHz</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>ATD 10-Bit Conversion Period</td>
<td>Conv, Time at 2.0MHz ATD Clock ( f_{ATDCCLK} )</td>
<td>( N_{CONV10} ), ( T_{CONV10} )</td>
<td>14</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>ATD 8-Bit Conversion Period</td>
<td>Conv, Time at 2.0MHz ATD Clock ( f_{ATDCCLK} )</td>
<td>( N_{CONV8} ), ( T_{CONV8} )</td>
<td>12</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Recovery Time (( V_{DDA}=5.0 ) Volts)</td>
<td>( t_{REC} )</td>
<td></td>
<td></td>
<td>20</td>
<td>μs</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>Reference Supply current</td>
<td>2 ATD blocks on</td>
<td>( I_{REF} )</td>
<td></td>
<td>0.750</td>
<td>mA</td>
</tr>
<tr>
<td>8</td>
<td>P</td>
<td>Reference Supply current</td>
<td>1 ATD block on</td>
<td>( I_{REF} )</td>
<td></td>
<td>0.375</td>
<td>mA</td>
</tr>
</tbody>
</table>

NOTES:
1. Full accuracy is not guaranteed when differential voltage is less than 4.50V
2. The minimum time assumes a final sample period of 2 ATD clocks cycles while the maximum time assumes a final sample period of 16 ATD clocks.

A.2.2 Factors influencing accuracy

Three factors - source resistance, source capacitance and current injection - have an influence on the accuracy of the ATD.

A.2.2.1 Source Resistance:

Due to the input pin leakage current as specified in Table A-6 in conjunction with the source resistance there will be a voltage drop from the signal source to the ATD input. The maximum source resistance \( R_S \)
specifies results in an error of less than 1/2 LSB (2.5mV) at the maximum leakage current. If device or operating conditions are less than worst case or leakage-induced error is acceptable, larger values of source resistance is allowed.

### A.2.2.2 Source Capacitance

When sampling an additional internal capacitor is switched to the input. This can cause a voltage drop due to charge sharing with the external and the pin capacitance. For a maximum sampling error of the input voltage \( \leq 1 \text{LSB} \), then the external filter capacitor, \( C_f \geq 1024 \times (C_{INS} - C_{INN}) \).

### A.2.2.3 Current Injection

There are two cases to consider.

1. A current is injected into the channel being converted. The channel being stressed has conversion values of $3FF$ (SFF in 8-bit mode) for analog inputs greater than \( V_{RH} \) and $000$ for values less than \( V_{RL} \) unless the current is higher than specified as disruptive condition.

2. Current is injected into pins in the neighborhood of the channel being converted. A portion of this current is picked up by the channel (coupling ratio \( K \)). This additional current impacts the accuracy of the conversion depending on the source resistance.

The additional input voltage error on the converted channel can be calculated as \( V_{ERR} = K \times R_S \times I_{INJ} \), with \( I_{INJ} \) being the sum of the currents injected into the two pins adjacent to the converted channel.

<table>
<thead>
<tr>
<th>Table A-9 ATD Electrical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions are shown in Table A-4 unless otherwise noted</td>
</tr>
<tr>
<td>Num</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
A.2.3 ATD accuracy

Table A-10 specifies the ATD conversion performance excluding any errors due to current injection, input capacitance and source resistance.

Table A-10 ATD Conversion Performance

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>10-Bit Resolution</td>
<td>LSB</td>
<td>5</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>10-Bit Differential Nonlinearity</td>
<td>DNL</td>
<td>-1</td>
<td>1</td>
<td></td>
<td>Counts</td>
</tr>
<tr>
<td>3</td>
<td>P</td>
<td>10-Bit Integral Nonlinearity</td>
<td>INL</td>
<td>-2.5</td>
<td>±1.5</td>
<td>2.5</td>
<td>Counts</td>
</tr>
<tr>
<td>4</td>
<td>P</td>
<td>10-Bit Absolute Error(^1)</td>
<td>AE</td>
<td>-3</td>
<td>±2.0</td>
<td>3</td>
<td>Counts</td>
</tr>
<tr>
<td>5</td>
<td>P</td>
<td>8-Bit Resolution</td>
<td>LSB</td>
<td>20</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>6</td>
<td>P</td>
<td>8-Bit Differential Nonlinearity</td>
<td>DNL</td>
<td>-0.5</td>
<td>0.5</td>
<td></td>
<td>Counts</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>8-Bit Integral Nonlinearity</td>
<td>INL</td>
<td>-1.0</td>
<td>±0.5</td>
<td>1.0</td>
<td>Counts</td>
</tr>
<tr>
<td>8</td>
<td>P</td>
<td>8-Bit Absolute Error(^1)</td>
<td>AE</td>
<td>-1.5</td>
<td>±1.0</td>
<td>1.5</td>
<td>Counts</td>
</tr>
</tbody>
</table>

NOTES:
1. These values include the quantization error which is inherently 1/2 count for any A/D converter.

For the following definitions see also Figure A-1.

Differential Non-Linearity (DNL) is defined as the difference between two adjacent switching steps.

\[
DNL(i) = \frac{V_i - V_{i-1}}{1\text{ LSB}} - 1
\]

The Integral Non-Linearity (INL) is defined as the sum of all DNLs:

\[
INL(n) = \sum_{i=1}^{n} DNL(i) = \frac{V_n - V_0}{1\text{ LSB}} - n
\]
Figure A-1  ATD Accuracy Definitions

NOTE: Figure A-1 shows only definitions, for specification values refer to Table A-10.
A.3 NVM, Flash and EEPROM

**NOTE:** Unless otherwise noted the abbreviation NVM (Non Volatile Memory) is used for both Flash and EEPROM.

A.3.1 NVM timing

The time base for all NVM program or erase operations is derived from the oscillator. A minimum oscillator frequency \( f_{\text{NVMOSC}} \) is required for performing program or erase operations. The NVM modules do not have any means to monitor the frequency and will not prevent program or erase operation at frequencies above or below the specified minimum. Attempting to program or erase the NVM modules at a lower frequency a full program or erase transition is not assured.

The Flash and EEPROM program and erase operations are timed using a clock derived from the oscillator using the FCLKDIV and ECLKDIV registers respectively. The frequency of this clock must be set within the limits specified as \( f_{\text{NVMOP}} \).

The minimum program and erase times shown in Table A-11 are calculated for maximum \( f_{\text{NVMOP}} \) and maximum \( f_{\text{bus}} \). The maximum times are calculated for minimum \( f_{\text{NVMOP}} \) and a \( f_{\text{bus}} \) of 2MHz.

A.3.1.1 Single Word Programming

The programming time for single word programming is dependant on the bus frequency as well as on the frequency \( f_{\text{NVMOP}} \) and can be calculated according to the following formula.

\[
t_{\text{swpgm}} = 9 \cdot \frac{1}{f_{\text{NVMOP}}} + 25 \cdot \frac{1}{f_{\text{bus}}}
\]

A.3.1.2 Burst Programming

This applies only to the Flash where up to 32 words in a row can be programmed consecutively using burst programming by keeping the command pipeline filled. The time to program a consecutive word can be calculated as:

\[
t_{\text{bwpgm}} = 4 \cdot \frac{1}{f_{\text{NVMOP}}} + 9 \cdot \frac{1}{f_{\text{bus}}}
\]

The time to program a whole row is:

\[
t_{\text{brpgm}} = t_{\text{swpgm}} + 31 \cdot t_{\text{bwpgm}}
\]

Burst programming is more than 2 times faster than single word programming.
A.3.1.3 Sector Erase

Erasing a 512 byte Flash sector or a 4 byte EEPROM sector takes:

\[ t_{\text{era}} \approx 4000 \cdot \frac{1}{f_{\text{NVMOP}}} \]

The setup time can be ignored for this operation.

A.3.1.4 Mass Erase

Erasing a NVM block takes:

\[ t_{\text{mass}} \approx 20000 \cdot \frac{1}{f_{\text{NVMOP}}} \]

The setup time can be ignored for this operation.

A.3.1.5 Blank Check

The time it takes to perform a blank check on the Flash or EEPROM is dependant on the location of the first non-blank word starting at relative address zero. It takes one bus cycle per word to verify plus a setup of the command.

\[ t_{\text{check}} \approx \text{location} \cdot t_{\text{cyc}} + 10 \cdot t_{\text{cyc}} \]

Table A-11 NVM Timing Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D</td>
<td>External Oscillator Clock</td>
<td>( f_{\text{NVMOSC}} )</td>
<td>0.5</td>
<td></td>
<td>50</td>
<td>MHz</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>Bus frequency for Programming or Erase Operations</td>
<td>( f_{\text{NVMBUS}} )</td>
<td>1</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Operating Frequency</td>
<td>( f_{\text{NVMOP}} )</td>
<td>150</td>
<td></td>
<td>200</td>
<td>kHz</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Single Word Programming Time</td>
<td>( t_{\text{swpgm}} )</td>
<td>46</td>
<td>2</td>
<td>74.5</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Flash Burst Programming consecutive word</td>
<td>( t_{\text{bwpgm}} )</td>
<td>20.4</td>
<td>2</td>
<td>31</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Flash Burst Programming Time for 32 Words</td>
<td>( t_{\text{brpgm}} )</td>
<td>678.4</td>
<td>2</td>
<td>1035.5</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>7</td>
<td>P</td>
<td>Sector Erase Time</td>
<td>( t_{\text{era}} )</td>
<td>20</td>
<td>5</td>
<td>26.7</td>
<td>ms</td>
</tr>
<tr>
<td>8</td>
<td>P</td>
<td>Mass Erase Time</td>
<td>( t_{\text{mass}} )</td>
<td>100</td>
<td>5</td>
<td>133</td>
<td>ms</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Blank Check Time Flash per block</td>
<td>( t_{\text{check}} )</td>
<td>11</td>
<td>6</td>
<td>32778</td>
<td>( t_{\text{cyc}} )</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Blank Check Time EEPROM per block</td>
<td>( t_{\text{check}} )</td>
<td>11</td>
<td>6</td>
<td>2058</td>
<td>( t_{\text{cyc}} )</td>
</tr>
</tbody>
</table>

Notes:
1. Restrictions for oscillator in crystal mode apply!
2. Minimum Programming times are achieved under maximum NVM operating frequency \( f_{\text{NVMOP}} \) and maximum bus frequency \( f_{\text{bus}} \)
A.3.2  NVM Reliability

The reliability of the NVM blocks is guaranteed by stress test during qualification, constant process monitors and burn-in to screen early life failures.

The failure rates for data retention and program/erase cycling are specified at the operating conditions noted.

The program/erase cycle count on the sector is incremented every time a sector or mass erase event is executed.

NOTE: All values shown in Table A-12 are target values and subject to further extensive characterization.

Table A-12  NVM Reliability Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Cycles</th>
<th>Data Retention Lifetime</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>Flash/EEPROM (-40C to +125C)</td>
<td>10</td>
<td>15</td>
<td>Years</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>EEPROM (-40C to +125C)</td>
<td>10,000</td>
<td>5</td>
<td>Years</td>
</tr>
</tbody>
</table>

NOTE: Flash cycling performance is 10 cycles at -40C to +125C. Data retention is specified for 15 years.

NOTE: EEPROM cycling performance is 10K cycles at -40C to +125C. Data retention is specified for 5 years on words after cycling 10K times. However if only 10 cycles are executed on a word the data retention is specified for 15 years.
A.4 Voltage Regulator

The on-chip voltage regulator is intended to supply the internal logic and oscillator circuits. No external DC load is allowed.

Table A-13 Voltage Regulator Recommended Load Capacitances

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Capacitance on VDD1, 2</td>
<td>$C_{LVDD}$</td>
<td></td>
<td>220</td>
<td></td>
<td>nF</td>
</tr>
<tr>
<td>Load Capacitance on VDDPLL</td>
<td>$C_{LVDDPLL}$</td>
<td></td>
<td>220</td>
<td></td>
<td>nF</td>
</tr>
</tbody>
</table>
A.5 Reset, Oscillator and PLL

This section summarizes the electrical characteristics of the various startup scenarios for Oscillator and Phase-Locked-Loop (PLL).

A.5.1 Startup

Table A-14 summarizes several startup characteristics explained in this section. Detailed description of the startup behavior can be found in the Clock and Reset Generator (CRG) Block User Guide.

Table A-14 Startup Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T</td>
<td>POR release level</td>
<td>V_PORR</td>
<td>2.07</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>T</td>
<td>POR assert level</td>
<td>V_PORA</td>
<td>0.97</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Reset input pulse width, minimum input time</td>
<td>PW_RSTL</td>
<td>2</td>
<td>t_osc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Startup from Reset</td>
<td>n_RST</td>
<td>192</td>
<td>196</td>
<td>n_osc</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Interrupt pulse width, IRQ edge-sensitive mode</td>
<td>PW_IRQ</td>
<td>20</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Wait recovery startup time</td>
<td>t_WRS</td>
<td>14</td>
<td>t_cyc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A.5.1.1 POR

The release level V_PORR and the assert level V_PORA are derived from the VDD supply. They are also valid if the device is powered externally. After releasing the POR reset the oscillator and the clock quality check are started. If after a time t_CQOUT no valid oscillation is detected, the MCU will start using the internal self clock. The fastest startup time possible is given by n_uposc.

A.5.1.2 SRAM Data Retention

Provided an appropriate external reset signal is applied to the MCU, preventing the CPU from executing code when VDD5 is out of specification limits, the SRAM contents integrity is guaranteed if after the reset the PORF bit in the CRG Flags Register has not been set.

A.5.1.3 External Reset

When external reset is asserted for a time greater than PW_RSTL the CRG module generates an internal reset, and the CPU starts fetching the reset vector without doing a clock quality check, if there was an oscillation before reset.
A.5.1.4  Stop Recovery

Out of STOP the controller can be woken up by an external interrupt. A clock quality check as after POR is performed before releasing the clocks to the system.

A.5.1.5  Pseudo Stop and Wait Recovery

The recovery from Pseudo STOP and Wait are essentially the same since the oscillator was not stopped in both modes. The controller can be woken up by internal or external interrupts. After $t_{\text{wts}}$, the CPU starts fetching the interrupt vector.

A.5.2  Oscillator

The device features an internal Colpitts oscillator. By asserting the XCLKS input during reset this oscillator can be bypassed allowing the input of a square wave. Before asserting the oscillator to the internal system clocks the quality of the oscillation is checked for each start from either power-on, STOP or oscillator fail. $t_{\text{CQOUT}}$ specifies the maximum time before switching to the internal self clock mode after POR or STOP if a proper oscillation is not detected. The quality check also determines the minimum oscillator start-up time $t_{\text{UPOSC}}$. The device also features a clock monitor. A Clock Monitor Failure is asserted if the frequency of the incoming clock signal is below the Assert Frequency $f_{\text{CMFA}}$.

Table A-15  Oscillator Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
<td>Crystal oscillator range</td>
<td>$f_{\text{OSC}}$</td>
<td>0.5</td>
<td>16</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>Startup Current</td>
<td>$i_{\text{OS}}$</td>
<td>100</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Oscillator start-up time</td>
<td>$t_{\text{UPOSC}}$</td>
<td></td>
<td></td>
<td>100²</td>
<td>ms</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Clock Quality check time-out</td>
<td>$t_{\text{CQOUT}}$</td>
<td>0.45</td>
<td></td>
<td>2.5</td>
<td>s</td>
</tr>
<tr>
<td>5</td>
<td>P</td>
<td>Clock Monitor Failure Assert Frequency</td>
<td>$f_{\text{CMFA}}$</td>
<td>50</td>
<td>200</td>
<td></td>
<td>KHz</td>
</tr>
<tr>
<td>6</td>
<td>P</td>
<td>External square wave input frequency³</td>
<td>$f_{\text{EXT}}$</td>
<td>0.5</td>
<td></td>
<td>50</td>
<td>MHz</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>External square wave pulse width low</td>
<td>$t_{\text{EXTL}}$</td>
<td>9.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>External square wave pulse width high</td>
<td>$t_{\text{EXTH}}$</td>
<td>9.5</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>External square wave rise time</td>
<td>$t_{\text{EXTR}}$</td>
<td></td>
<td></td>
<td>1</td>
<td>ns</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>External square wave fall time</td>
<td>$t_{\text{EXTF}}$</td>
<td></td>
<td></td>
<td>1</td>
<td>ns</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Input Capacitance (EXTAL, XTAL pins)</td>
<td>$C_{\text{IN}}$</td>
<td>9</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>12</td>
<td>C</td>
<td>DC Operating Bias in Colpitts Configuration on EXTAL Pin</td>
<td>$V_{\text{DCBIAS}}$</td>
<td></td>
<td>1.1</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

NOTES:
1. $f_{\text{OSC}} = 4$MHz, $C = 220pF$.
2. Maximum value is for extreme cases using high Q, low frequency crystals
3. XCLKS = 0 during reset
A.5.3 Phase Locked Loop

The oscillator provides the reference clock for the PLL. The PLL’s Voltage Controlled Oscillator (VCO) is also the system clock source in self clock mode.

A.5.3.1 XFC Component Selection

This section describes the selection of the XFC components to achieve a good filter characteristics.

![Basic PLL functional diagram](image)

The following procedure can be used to calculate the resistance and capacitance values using typical values for $K_1$, $f_1$ and $i_{ch}$ from **Table A-16**.

The VCO Gain at the desired VCO output frequency is approximated by:

$$K_V = \frac{(f_1 - f_{vco})}{K_1 \cdot 1V}$$

The phase detector relationship is given by:

$$K_\Phi = -|i_{ch}| \cdot K_V$$

$i_{ch}$ is the current in tracking mode.
The loop bandwidth \( f_C \) should be chosen to fulfill the Gardner’s stability criteria by at least a factor of 10, typical values are 50. \( \zeta = 0.9 \) ensures a good transient response.

\[
 f_C < \frac{2 \cdot \zeta \cdot f_{\text{ref}}}{\pi \cdot (\zeta + \sqrt{1 + \zeta^2})} \cdot \frac{1}{50} \quad \Rightarrow \quad f_C < \frac{f_{\text{ref}}}{4 \cdot 50} \quad (\zeta = 0.9)
\]

And finally the frequency relationship is defined as

\[
 n = \frac{f_{\text{VCO}}}{f_{\text{ref}}} = 2 \cdot (\text{synr} + 1)
\]

With the above inputs the resistance can be calculated as:

\[
 R = \frac{2 \cdot \pi \cdot n \cdot f_C}{K_\Phi}
\]

The capacitance \( C_s \) can now be calculated as:

\[
 C_s = \frac{2 \cdot \zeta^2}{\pi \cdot f_C \cdot R} \approx 0.516 \cdot \frac{f_C}{f_C \cdot R} \quad (\zeta = 0.9)
\]

The capacitance \( C_p \) should be chosen in the range of:

\[
 C_s / 20 \leq C_p \leq C_s / 10
\]

The stabilization delays shown in Table A-16 are dependant on PLL operational settings and external component selection (e.g. crystal, XFC filter).

A.5.3.2 Jitter Information

The basic functionality of the PLL is shown in Figure A-2. With each transition of the clock \( f_{\text{cmp}} \), the deviation from the reference clock \( f_{\text{ref}} \) is measured and input voltage to the VCO is adjusted accordingly. The adjustment is done continuously with no abrupt changes in the clock output frequency. Noise, voltage, temperature and other factors cause slight variations in the control loop resulting in a clock jitter. This jitter affects the real minimum and maximum clock periods as illustrated in Figure A-3.
The relative deviation of \( t_{\text{nom}} \) is at its maximum for one clock period, and decreases towards zero for larger number of clock periods (N).

Defining the jitter as:

\[
J(N) = \max \left( \left| 1 - \frac{t_{\text{max}}(N)}{N \cdot t_{\text{nom}}} \right|, \left| 1 - \frac{t_{\text{min}}(N)}{N \cdot t_{\text{nom}}} \right| \right)
\]

For \( N < 100 \), the following equation is a good fit for the maximum jitter:

\[
J(N) = \frac{j_1}{\sqrt{N}} + j_2
\]
This is very important to notice with respect to timers, serial modules where a pre-scaler will eliminate the effect of the jitter to a large extent.

### Table A-16  PLL Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Self Clock Mode frequency</td>
<td>$f_{SCM}$</td>
<td>1</td>
<td></td>
<td>5.5</td>
<td>MHz</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>VCO locking range</td>
<td>$f_{VCO}$</td>
<td>8</td>
<td></td>
<td>50</td>
<td>MHz</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Lock Detector transition from Acquisition to Tracking mode</td>
<td>$</td>
<td>A_{HK}</td>
<td>$</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Lock Detection</td>
<td>$</td>
<td>A_{Lock}</td>
<td>$</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Un-Lock Detection</td>
<td>$</td>
<td>A_{unl}</td>
<td>$</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Lock Detector transition from Tracking to Acquisition mode</td>
<td>$</td>
<td>A_{unt}</td>
<td>$</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>C</td>
<td>PLLON Total Stabilization delay (Auto Mode)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$t_{stab}$</td>
<td>0.5</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>PLLON Acquisition mode stabilization delay&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$t_{acq}$</td>
<td>0.3</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>PLLON Tracking mode stabilization delay&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$t_{al}$</td>
<td>0.2</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Fitting parameter VCO loop gain</td>
<td>$K_1$</td>
<td>-120</td>
<td></td>
<td></td>
<td>MHz/V</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Fitting parameter VCO loop frequency</td>
<td>$f_1$</td>
<td>75</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>Charge pump current acquisition mode</td>
<td>$</td>
<td>i_{ch}</td>
<td>$</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>D</td>
<td>Charge pump current tracking mode</td>
<td>$</td>
<td>i_{chl}</td>
<td>$</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>C</td>
<td>Jitter fit parameter&lt;sup&gt;1&lt;/sup&gt;</td>
<td>$j_1$</td>
<td>1.1</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>15</td>
<td>C</td>
<td>Jitter fit parameter&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$j_2$</td>
<td>0.13</td>
<td></td>
<td></td>
<td>%</td>
</tr>
</tbody>
</table>

**NOTES:**

1. % deviation from target frequency
2. $f_{REF} = 4$MHz, $f_{BUS} = 25$MHz equivalent $f_{VCO} = 50$MHz: REFDV = #$03, SYN = #$018, Cs = 4.7nF, Cp = 470pF, Rs = 10KΩ.
## A.6 MSCAN

### Table A-17 MSCAN Wake-up Pulse Characteristics

Conditions are shown in Table A-4 unless otherwise noted.

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>MSCAN Wake-up dominant pulse filtered</td>
<td>t(_{WUP})</td>
<td>2</td>
<td></td>
<td>2</td>
<td>(\mu s)</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>MSCAN Wake-up dominant pulse pass</td>
<td>t(_{WUP})</td>
<td>5</td>
<td></td>
<td></td>
<td>(\mu s)</td>
</tr>
</tbody>
</table>
A.7 SPI

A.7.1 Master Mode

Figure A-5 and Figure A-6 illustrate the master mode timing. Timing values are shown in Table A-18.

1. If configured as output.
2. LSBF = 0. For LSBF = 1, bit order is LSB, bit 1, ..., bit 6, MSB.

Figure A-5  SPI Master Timing (CPHA = 0)
Figure A-6  SPI Master Timing (CPHA =1)

Table A-18  SPI Master Mode Timing Characteristics

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Operating Frequency</td>
<td>f_{op}</td>
<td>1/4</td>
<td>f_{bus}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P</td>
<td>SCK Period ( t_{sck} = 1./f_{op} )</td>
<td>( t_{sck} )</td>
<td>4</td>
<td>2048</td>
<td>( t_{sck} )</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>Enable Lead Time</td>
<td>( t_{lead} )</td>
<td>1/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Enable Lag Time</td>
<td>( t_{lag} )</td>
<td>1/2</td>
<td></td>
<td>( t_{lag} )</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Clock (SCK) High or Low Time</td>
<td>( t_{w_{sck}} )</td>
<td>( t_{bus} - 30 )</td>
<td>1024 ( t_{bus} )</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Data Setup Time (Inputs)</td>
<td>( t_{su} )</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Data Hold Time (Inputs)</td>
<td>( t_{hi} )</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Data Valid (after Enable Edge)</td>
<td>( t_{v} )</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Data Hold Time (Outputs)</td>
<td>( t_{ho} )</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Rise Time Inputs and Outputs</td>
<td>( t_{r} )</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>Fall Time Inputs and Outputs</td>
<td>( t_{f} )</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. The numbers 7, 8 in the column labeled “Num” are missing. This has been done on purpose to be consistent between the Master and the Slave timing shown in Table A-19.
A.7.2 Slave Mode

Figure A-7 and Figure A-8 illustrate the slave mode timing. Timing values are shown in Table A-19.

**Figure A-7** SPI Slave Timing (CPHA = 0)

**Figure A-8** SPI Slave Timing (CPHA = 1)
### Table A-19 SPI Slave Mode Timing Characteristics

Conditions are shown in Table A-4 unless otherwise noted, CLOAD = 200pF on all outputs

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Operating Frequency</td>
<td>( f_{\text{op}} )</td>
<td>DC</td>
<td>( 1/4 )</td>
<td>( f_{\text{bus}} )</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P</td>
<td>SCK Period ( t_{\text{sck}} = 1/f_{\text{op}} )</td>
<td>( t_{\text{sck}} )</td>
<td>4</td>
<td>2048</td>
<td>( t_{\text{bus}} )</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>Enable Lead Time</td>
<td>( t_{\text{lead}} )</td>
<td>1</td>
<td></td>
<td></td>
<td>( t_{\text{cyc}} )</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Enable Lag Time</td>
<td>( t_{\text{lag}} )</td>
<td>1</td>
<td></td>
<td></td>
<td>( t_{\text{cyc}} )</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Clock (SCK) High or Low Time</td>
<td>( t_{\text{wsck}} )</td>
<td>( t_{\text{cyc}} - 30 )</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Data Setup Time (Inputs)</td>
<td>( t_{\text{su}} )</td>
<td>25</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Data Hold Time (Inputs)</td>
<td>( t_{\text{hi}} )</td>
<td>25</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>Slave Access Time</td>
<td>( t_{\text{a}} )</td>
<td>1</td>
<td></td>
<td></td>
<td>( t_{\text{cyc}} )</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>Slave MISO Disable Time</td>
<td>( t_{\text{dis}} )</td>
<td>1</td>
<td></td>
<td></td>
<td>( t_{\text{cyc}} )</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Data Valid (after SCK Edge)</td>
<td>( t_{v} )</td>
<td>25</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Data Hold Time (Outputs)</td>
<td>( t_{\text{ho}} )</td>
<td>0</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Rise Time Inputs and Outputs</td>
<td>( t_{r} )</td>
<td>25</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>Fall Time Inputs and Outputs</td>
<td>( t_{f} )</td>
<td>25</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>
A.8 External Bus Timing

A timing diagram of the external multiplexed-bus is illustrated in Figure A-9 with the actual timing values shown on table Table A-20. All major bus signals are included in the diagram. While both a data write and data read cycle are shown, only one or the other would occur on a particular bus cycle.

A.8.1 General Muxed Bus Timing

The expanded bus timings are highly dependent on the load conditions. The timing parameters shown assume a balanced load across all outputs.
Figure A-9 General External Bus Timing
### Table A-20  Expanded Bus Timing Characteristics

Conditions are shown in Table A-4 unless otherwise noted, $C_{LOAD} = 50\text{pF}$.

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
<td>Frequency of operation (E-clock)</td>
<td>$f_o$</td>
<td>0</td>
<td></td>
<td>25.0</td>
<td>MHz</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>Cycle time</td>
<td>$t_{cyc}$</td>
<td>40</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Pulse width, E low</td>
<td>$PW_{EL}$</td>
<td>19</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>Pulse width, E high¹</td>
<td>$PW_{EH}$</td>
<td>19</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>Address delay time</td>
<td>$t_{AD}$</td>
<td></td>
<td>8</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>6</td>
<td>D</td>
<td>Address valid time to E rise ($PW_{EL} - t_{AD}$)</td>
<td>$t_{AV}$</td>
<td>11</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>Muxed address hold time</td>
<td>$t_{MAH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>Address hold to data valid</td>
<td>$t_{AHDS}$</td>
<td>7</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>Data hold to address</td>
<td>$t_{DHA}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>Read data setup time</td>
<td>$t_{DSR}$</td>
<td>13</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>11</td>
<td>D</td>
<td>Read data hold time</td>
<td>$t_{DHR}$</td>
<td>0</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>Write data delay time</td>
<td>$t_{DDW}$</td>
<td></td>
<td>7</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>13</td>
<td>D</td>
<td>Write data hold time</td>
<td>$t_{DHW}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>14</td>
<td>D</td>
<td>Write data setup time¹ ($PW_{EH} - t_{DDW}$)</td>
<td>$t_{DSW}$</td>
<td>12</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>15</td>
<td>D</td>
<td>Address access time¹ ($t_{cyc} - t_{AD} - t_{DSR}$)</td>
<td>$t_{ACCA}$</td>
<td>19</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>16</td>
<td>D</td>
<td>E high access time¹ ($PW_{EH} - t_{DSR}$)</td>
<td>$t_{ACCE}$</td>
<td>6</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>17</td>
<td>D</td>
<td>Non-multiplexed address delay time</td>
<td>$t_{NAD}$</td>
<td></td>
<td>6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>18</td>
<td>D</td>
<td>Non-muxed address valid to E rise ($PW_{EL} - t_{NAD}$)</td>
<td>$t_{NAV}$</td>
<td>15</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>19</td>
<td>D</td>
<td>Non-multiplexed address hold time</td>
<td>$t_{NAH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>20</td>
<td>D</td>
<td>Chip select delay time</td>
<td>$t_{CSD}$</td>
<td></td>
<td>16</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>21</td>
<td>D</td>
<td>Chip select access time¹ ($t_{cyc} - t_{CSD} - t_{DSR}$)</td>
<td>$t_{ACCS}$</td>
<td>11</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>22</td>
<td>D</td>
<td>Chip select hold time</td>
<td>$t_{CSH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>23</td>
<td>D</td>
<td>Chip select negated time</td>
<td>$t_{CSN}$</td>
<td>8</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>24</td>
<td>D</td>
<td>Read/write delay time</td>
<td>$t_{RWD}$</td>
<td></td>
<td>7</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>25</td>
<td>D</td>
<td>Read/write valid time to E rise ($PW_{EL} - t_{RWD}$)</td>
<td>$t_{RWV}$</td>
<td>14</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>26</td>
<td>D</td>
<td>Read/write hold time</td>
<td>$t_{RWH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>27</td>
<td>D</td>
<td>Low strobe delay time</td>
<td>$t_{LSD}$</td>
<td></td>
<td>7</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>28</td>
<td>D</td>
<td>Low strobe valid time to E rise ($PW_{EL} - t_{LSD}$)</td>
<td>$t_{LSV}$</td>
<td>14</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>29</td>
<td>D</td>
<td>Low strobe hold time</td>
<td>$t_{LSH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>30</td>
<td>D</td>
<td>NOACC strobe delay time</td>
<td>$t_{NOD}$</td>
<td></td>
<td>7</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>31</td>
<td>D</td>
<td>NOACC valid time to E rise ($PW_{EL} - t_{NOD}$)</td>
<td>$t_{NOV}$</td>
<td>14</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>
### Table A-20 Expanded Bus Timing Characteristics

Conditions are shown in Table A-4 unless otherwise noted, $C_{LOAD} = 50pF$.

<table>
<thead>
<tr>
<th>Num</th>
<th>C</th>
<th>Rating</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>D</td>
<td>NOACC hold time</td>
<td>$t_{NOH}$</td>
<td>2</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>33</td>
<td>D</td>
<td>IPIPO[1:0] delay time</td>
<td>$t_{POD}$</td>
<td>2</td>
<td>7</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>34</td>
<td>D</td>
<td>IPIPO[1:0] valid time to E rise ($PW_{EL} - t_{POD}$)</td>
<td>$t_{POV}$</td>
<td>11</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>35</td>
<td>D</td>
<td>IPIPO[1:0] delay time$^1$ ($PW_{EH} - t_{P1V}$)</td>
<td>$t_{P1D}$</td>
<td>2</td>
<td>25</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>36</td>
<td>D</td>
<td>IPIPO[1:0] valid time to E fall</td>
<td>$t_{P1V}$</td>
<td>11</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Affected by clock stretch: add $N \times t_{cycle}$ where $N=0,1,2$ or 3, depending on the number of clock stretches.
Appendix B  Package Information

B.1 General

This section provides the physical dimensions of the MC9S12DP256B packages.
B.2 112-pin LQFP package

Figure B-1 112-pin LQFP mechanical dimensions (case no. 987)
B.3 80-pin QFP package

Figure B-2  80-pin QFP Mechanical Dimensions (case no. 841B)