

## MIXED SIGNAL MICROCONTROLLER

### FEATURES

- **Low Supply-Voltage Range: 1.8 V to 3.6 V**
- **Ultralow Power Consumption**
  - **Active Mode: 220  $\mu$ A at 1 MHz, 2.2 V**
  - **Standby Mode: 0.5  $\mu$ A**
  - **Off Mode (RAM Retention): 0.1  $\mu$ A**
- **Five Power-Saving Modes**
- **Ultrafast Wake-Up From Standby Mode in Less Than 1  $\mu$ s**
- **16-Bit RISC Architecture, 62.5-ns Instruction Cycle Time**
- **Basic Clock Module Configurations**
  - **Internal Frequencies up to 16 MHz With One Calibrated Frequency**
  - **Internal Very Low Power Low-Frequency (LF) Oscillator**
  - **32-kHz Crystal**
  - **External Digital Clock Source**
- **16-Bit Timer\_A With Two Capture/Compare Registers**
- **Brownout Detector**
- **On-Chip Comparator for Analog Signal Compare Function or Slope A/D (See [Table 1](#))**
- **Serial Onboard Programming, No External Programming Voltage Needed, Programmable Code Protection by Security Fuse**
- **On-Chip Emulation Logic With Spy-Bi-Wire Interface**
- **For Family Members Details, See [Table 1](#)**
- **Available in a 14-Pin Plastic Small-Outline Thin Package (TSSOP) (PW), 14-Pin Plastic Dual Inline Package (PDIP) (N), and 16-Pin QFN (RSA)**
- **For Complete Module Descriptions, See the *MSP430x2xx Family User's Guide* ([SLAU144](#))**

### DESCRIPTION

The Texas Instruments MSP430™ family of ultralow-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 1  $\mu$ s.

The MSP430G2x01 and MSP430G2x11 series is an ultralow-power mixed signal microcontroller with a built-in 16-bit timer and ten I/O pins. The MSP430G2x11 family members have a versatile analog comparator. For configuration details see [Table 1](#).

Typical applications include low-cost sensor systems that capture analog signals, convert them to digital values, and then process the data for display or for transmission to a host system.



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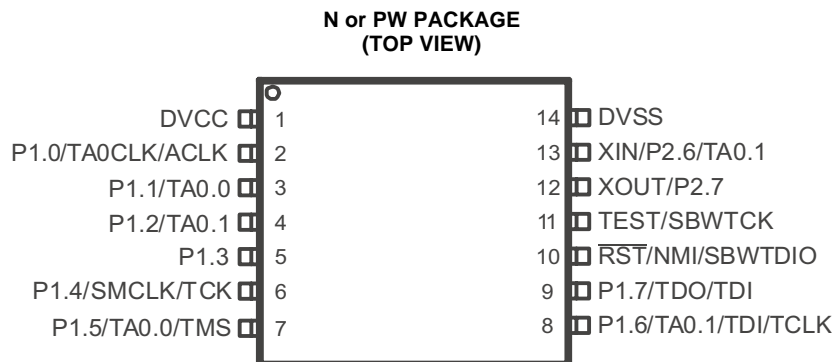
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**Table 1. Available Options<sup>(1)</sup>**

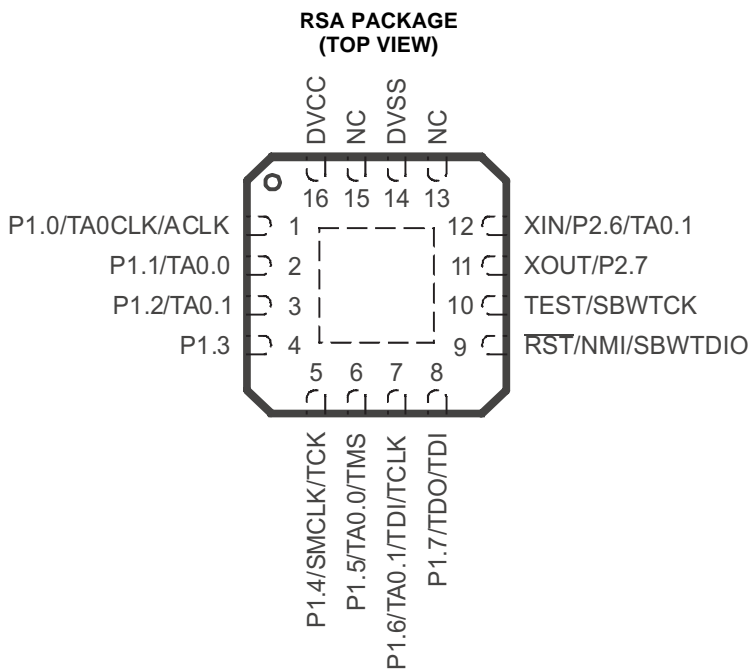
| Device   | BSL | EEM | Flash (KB) | RAM (B) | Timer_A | Comp_A+ Channel | Clock        | I/O | Package Type <sup>(2)</sup>   |
|--|-----|-----|------------|---------|---------|-----------------|--------------|-----|-------------------------------|
| MSP430G2211IRSA16<br>MSP430G2211IPW14<br>MSP430G2211IN14 | -   | 1   | 2          | 128     | 1x TA2  | 8               | LF, DCO, VLO | 10  | 16-QFN<br>14-TSSOP<br>14-PDIP |
| MSP430G2201IRSA16<br>MSP430G2201IPW14<br>MSP430G2201IN14 | -   | 1   | 2          | 128     | 1x TA2  | -               | LF, DCO, VLO | 10  | 16-QFN<br>14-TSSOP<br>14-PDIP |
| MSP430G2111IRSA16<br>MSP430G2111IPW14<br>MSP430G2111IN14 | -   | 1   | 1          | 128     | 1x TA2  | 8               | LF, DCO, VLO | 10  | 16-QFN<br>14-TSSOP<br>14-PDIP |
| MSP430G2101IRSA16<br>MSP430G2101IPW14<br>MSP430G2101IN14 | -   | 1   | 1          | 128     | 1x TA2  | -               | LF, DCO, VLO | 10  | 16-QFN<br>14-TSSOP<br>14-PDIP |
| MSP430G2001IRSA16<br>MSP430G2001IPW14<br>MSP430G2001IN14 | -   | 1   | 0.5        | 128     | 1x TA2  | -               | LF, DCO, VLO | 10  | 16-QFN<br>14-TSSOP<br>14-PDIP |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).
- (2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

## Device Pinout, MSP430G2x01



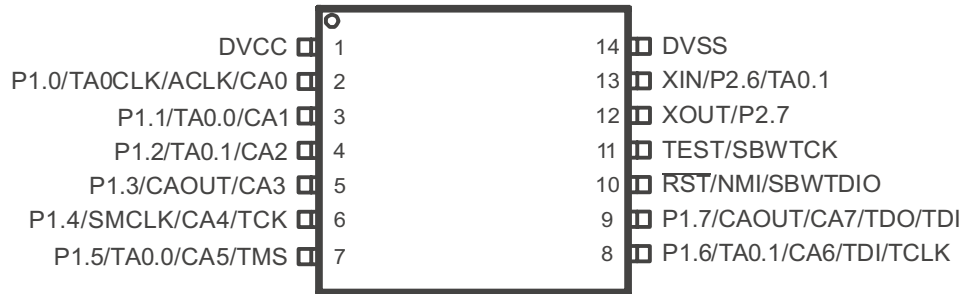
NOTE: See port schematics in [Application Information](#) for detailed I/O information.



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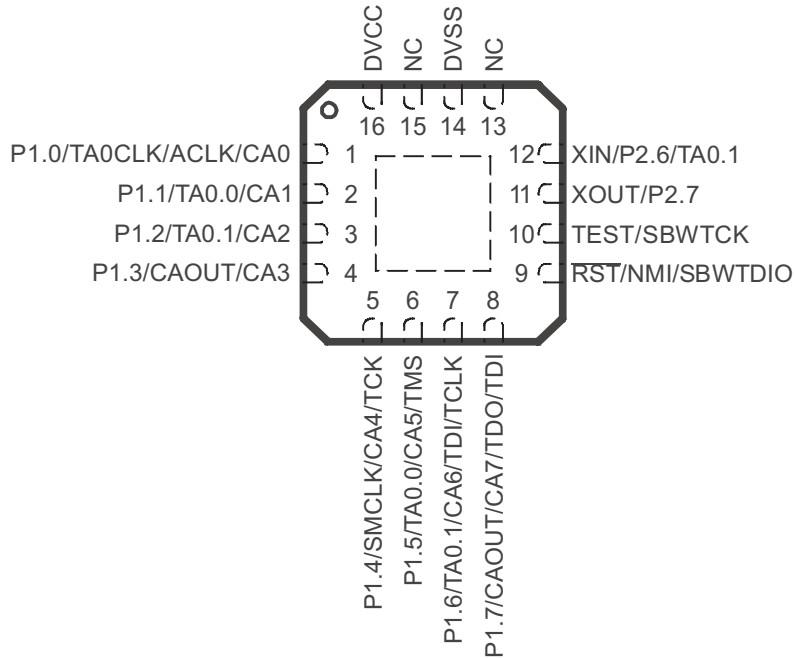
**Device Pinout, MSP430G2x11**

**N or PW PACKAGE  
(TOP VIEW)**



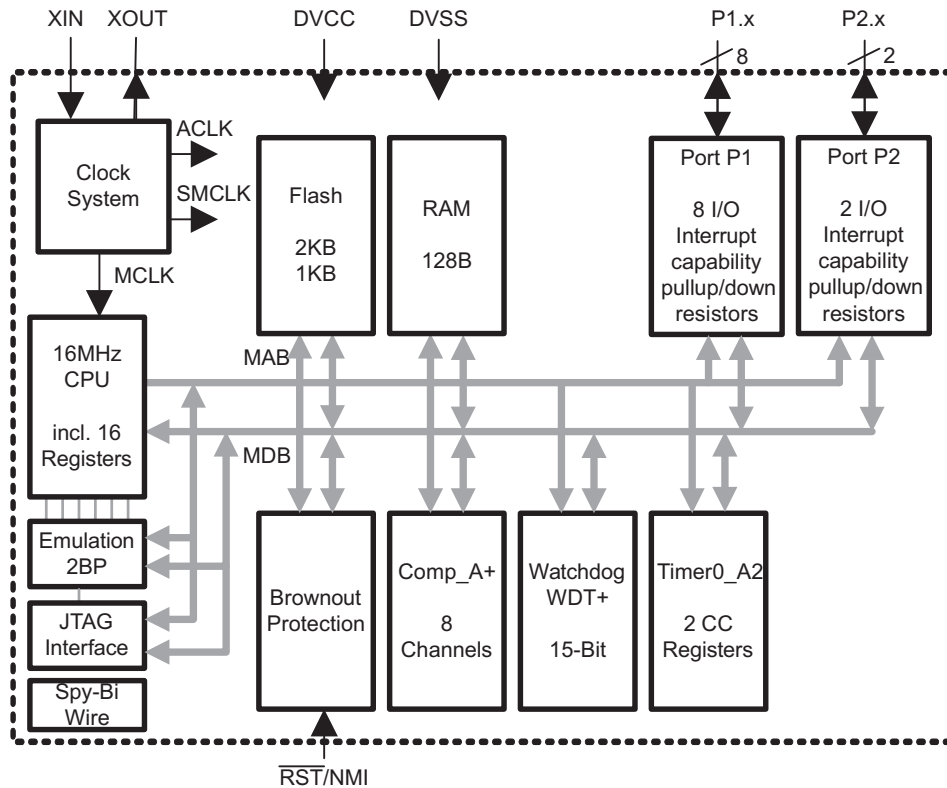
NOTE: See port schematics in [Application Information](#) for detailed I/O information.

**RSA PACKAGE  
(TOP VIEW)**

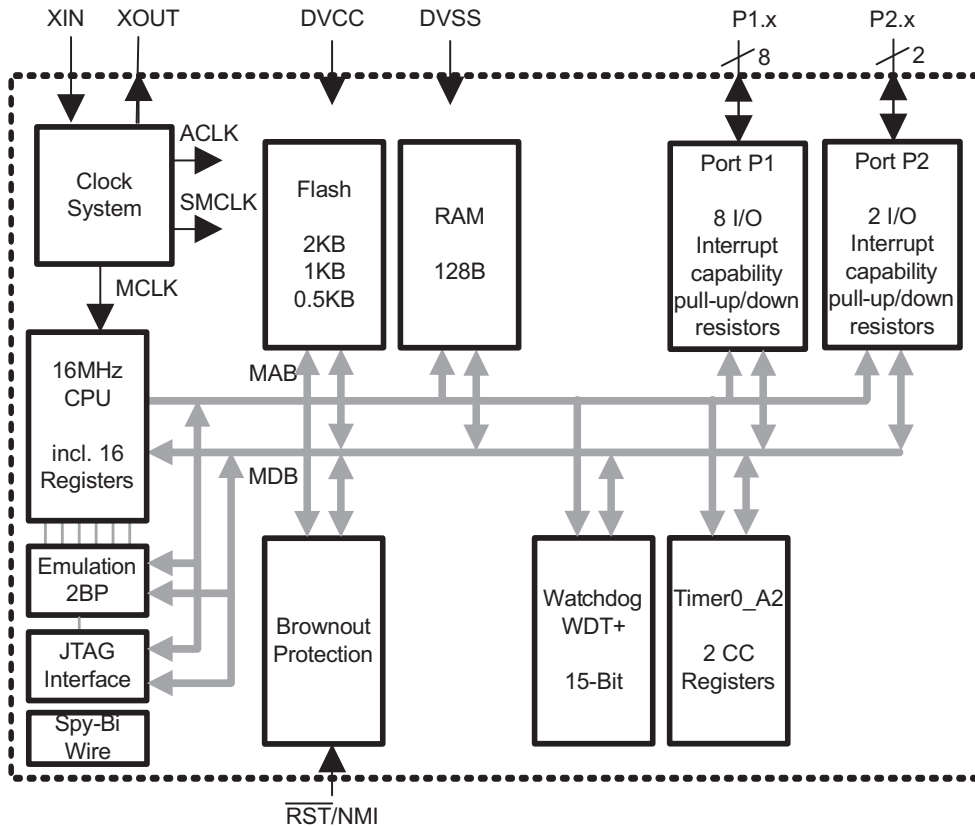


NOTE: See port schematics in [Application Information](#) for detailed I/O information.

Functional Block Diagram, MSP430G2x11



Functional Block Diagram, MSP430G2x01



**Table 2. Terminal Functions**

| TERMINAL  |             |           | I/O | DESCRIPTION   |
|---|-------------|-----------|-----|---|
| NAME  | NO.         |           |     |   |
|   | 14<br>N, PW | 16<br>RSA |     |   |
| P1.0/<br>TA0CLK/<br>ACLK/<br>CA0                  | 2           | 1         | I/O | General-purpose digital I/O pin<br>Timer0_A, clock signal TACLK input<br>ACLK signal output<br>Comparator_A+, CA0 input <sup>(1)</sup>  |
| P1.1/<br>TA0.0/<br>CA1                            | 3           | 2         | I/O | General-purpose digital I/O pin<br>Timer0_A, capture: CCI0A input, compare: Out0 output<br>Comparator_A+, CA1 input <sup>(1)</sup>  |
| P1.2/<br>TA0.1/<br>CA2                            | 4           | 3         | I/O | General-purpose digital I/O pin<br>Timer0_A, capture: CCI1A input, compare: Out1 output<br>Comparator_A+, CA2 input <sup>(1)</sup>  |
| P1.3/<br>CA3/<br>CAOUT                            | 5           | 4         | I/O | General-purpose digital I/O pin<br>Comparator_A+, CA3 input <sup>(1)</sup><br>Comparator_A+, output <sup>(1)</sup>  |
| P1.4/<br>SMCLK/<br>CA4/<br>TCK                    | 6           | 5         | I/O | General-purpose digital I/O pin<br>SMCLK signal output<br>Comparator_A+, CA4 input <sup>(1)</sup><br>JTAG test clock, input terminal for device programming and test                  |
| P1.5/<br>TA0.0/<br>CA5/<br>TMS                    | 7           | 6         | I/O | General-purpose digital I/O pin<br>Timer0_A, compare: Out0 output<br>Comparator_A+, CA5 input <sup>(1)</sup><br>JTAG test mode select, input terminal for device programming and test |
| P1.6/<br>TA0.1/<br>CA6/<br>TDI/TCLK               | 8           | 7         | I/O | General-purpose digital I/O pin<br>Timer0_A, compare: Out1 output<br>Comparator_A+, CA6 input <sup>(1)</sup><br>JTAG test data input or test clock input during programming and test  |
| P1.7/<br>CA7/<br>CAOUT/<br>TDO/TDI <sup>(2)</sup> | 9           | 8         | I/O | General-purpose digital I/O pin<br>CA7 input <sup>(1)</sup><br>Comparator_A+, output <sup>(1)</sup><br>JTAG test data output terminal or test data input during programming and test  |
| XIN/<br>P2.6/<br>TA0.1                            | 13          | 12        | I/O | Input terminal of crystal oscillator<br>General-purpose digital I/O pin<br>Timer0_A, compare: Out1 output   |
| XOUT/<br>P2.7                                     | 12          | 11        | I/O | Output terminal of crystal oscillator <sup>(3)</sup><br>General-purpose digital I/O pin   |
| RST/<br>NMI/<br>SBWTDIO                           | 10          | 9         | I   | Reset<br>Nonmaskable interrupt input<br>Spy-Bi-Wire test data input/output during programming and test  |
| TEST/<br>SBWTCK                                   | 11          | 10        | I   | Selects test mode for JTAG pins on Port 1. The device protection fuse is connected to TEST.<br>Spy-Bi-Wire test clock input during programming and test                               |
| DVCC  | 1           | 16        | NA  | Supply voltage  |
| DVSS  | 14          | 14        | NA  | Ground reference  |
| NC  | -           | 13, 15    | NA  | Not connected   |
| QFN Pad   | -           | Pad       | NA  | QFN package pad connection to V <sub>SS</sub> is recommended.   |

- (1) MSP430G2x11 only
- (2) TDO or TDI is selected via JTAG instruction.
- (3) If XOUT/P2.7 is used as an input, excess current flows until P2SEL.7 is cleared. This is due to the oscillator output driver connection to this pad after reset.

## SHORT-FORM DESCRIPTION

### CPU

The MSP430 CPU has a 16-bit RISC architecture that is highly transparent to the application. All operations, other than program-flow instructions, are performed as register operations in conjunction with seven addressing modes for source operand and four addressing modes for destination operand.

The CPU is integrated with 16 registers that provide reduced instruction execution time. The register-to-register operation execution time is one cycle of the CPU clock.

Four of the registers, R0 to R3, are dedicated as program counter, stack pointer, status register, and constant generator, respectively. The remaining registers are general-purpose registers.

Peripherals are connected to the CPU using data, address, and control buses, and can be handled with all instructions.

The instruction set consists of the original 51 instructions with three formats and seven address modes and additional instructions for the expanded address range. Each instruction can operate on word and byte data.

### Instruction Set

The instruction set consists of 51 instructions with three formats and seven address modes. Each instruction can operate on word and byte data. [Table 3](#) shows examples of the three types of instruction formats; [Table 4](#) shows the address modes.

|                          |           |
|--------------------------|-----------|
| Program Counter          | PC/R0     |
| Stack Pointer            | SP/R1     |
| Status Register          | SR/CG1/R2 |
| Constant Generator       | CG2/R3    |
| General-Purpose Register | R4        |
| General-Purpose Register | R5        |
| General-Purpose Register | R6        |
| General-Purpose Register | R7        |
| General-Purpose Register | R8        |
| General-Purpose Register | R9        |
| General-Purpose Register | R10       |
| General-Purpose Register | R11       |
| General-Purpose Register | R12       |
| General-Purpose Register | R13       |
| General-Purpose Register | R14       |
| General-Purpose Register | R15       |

**Table 3. Instruction Word Formats**

| INSTRUCTION FORMAT                | EXAMPLE   | OPERATION             |
|-----------------------------------|-----------|-----------------------|
| Dual operands, source-destination | ADD R4,R5 | R4 + R5 --> R5        |
| Single operands, destination only | CALL R8   | PC -->(TOS), R8-> PC  |
| Relative jump, un/conditional     | JNE       | Jump-on-equal bit = 0 |

**Table 4. Address Mode Descriptions<sup>(1)</sup>**

| ADDRESS MODE           | S | D | SYNTAX          | EXAMPLE          | OPERATION                           |
|------------------------|---|---|-----------------|------------------|-------------------------------------|
| Register               | ✓ | ✓ | MOV Rs,Rd       | MOV R10,R11      | R10 --> R11                         |
| Indexed                | ✓ | ✓ | MOV X(Rn),Y(Rm) | MOV 2(R5),6(R6)  | M(2+R5) - -> M(6+R6)                |
| Symbolic (PC relative) | ✓ | ✓ | MOV EDE,TONI    |                  | M(EDE) - -> M(TONI)                 |
| Absolute               | ✓ | ✓ | MOV &MEM,&TCDAT |                  | M(MEM) - -> M(TCDAT)                |
| Indirect               | ✓ |   | MOV @Rn,Y(Rm)   | MOV @R10,Tab(R6) | M(R10) - -> M(Tab+R6)               |
| Indirect autoincrement | ✓ |   | MOV @Rn+,Rm     | MOV @R10+,R11    | M(R10) - -> R11<br>R10 + 2 - -> R10 |
| Immediate              | ✓ |   | MOV #X,TONI     | MOV #45,TONI     | #45 - -> M(TONI)                    |

(1) S = source, D = destination

## Operating Modes

The MSP430 has one active mode and five software selectable low-power modes of operation. An interrupt event can wake up the device from any of the low-power modes, service the request, and restore back to the low-power mode on return from the interrupt program.

The following six operating modes can be configured by software:

- Active mode (AM)
  - All clocks are active
- Low-power mode 0 (LPM0)
  - CPU is disabled
  - ACLK and SMCLK remain active, MCLK is disabled
- Low-power mode 1 (LPM1)
  - CPU is disabled
  - ACLK and SMCLK remain active, MCLK is disabled
  - DCO's dc generator is disabled if DCO not used in active mode
- Low-power mode 2 (LPM2)
  - CPU is disabled
  - MCLK and SMCLK are disabled
  - DCO's dc generator remains enabled
  - ACLK remains active
- Low-power mode 3 (LPM3)
  - CPU is disabled
  - MCLK and SMCLK are disabled
  - DCO's dc generator is disabled
  - ACLK remains active
- Low-power mode 4 (LPM4)
  - CPU is disabled
  - ACLK is disabled
  - MCLK and SMCLK are disabled
  - DCO's dc generator is disabled
  - Crystal oscillator is stopped

## Interrupt Vector Addresses

The interrupt vectors and the power-up starting address are located in the address range 0FFFFh to 0FFC0h. The vector contains the 16-bit address of the appropriate interrupt handler instruction sequence.

If the reset vector (located at address 0FFFEh) contains 0FFFFh (for example, flash is not programmed) the CPU goes into LPM4 immediately after power-up.

**Table 5. Interrupt Sources, Flags, and Vectors**

| INTERRUPT SOURCE   | INTERRUPT FLAG                                    | SYSTEM INTERRUPT                                   | WORD ADDRESS        | PRIORITY        |
|--|---|--|---------------------|-----------------|
| Power-Up<br>External Reset<br>Watchdog Timer+<br>Flash key violation<br>PC out-of-range <sup>(1)</sup> | PORIFG<br>RSTIFG<br>WDTIFG<br>KEYV <sup>(2)</sup> | Reset  | 0FFFEh              | 31, highest     |
| NMI<br>Oscillator fault<br>Flash memory access violation   | NMIIFG<br>OFIFG<br>ACCVIFG <sup>(2)(3)</sup>      | (non)-maskable<br>(non)-maskable<br>(non)-maskable | 0FFFCCh             | 30              |
|  |   |  | 0FFFAh              | 29              |
|  |   |  | 0FFF8h              | 28              |
| Comparator_A+  | CAIFG <sup>(4)(5)</sup>                           |  | 0FFF6h              | 27              |
| Watchdog Timer+  | WDTIFG  | maskable   | 0FFF4h              | 26              |
| Timer_A2   | TACCR0 CCIFG <sup>(4)</sup>                       | maskable   | 0FFF2h              | 25              |
| Timer_A2   | TACCR1 CCIFG, TAIFG <sup>(2)(4)</sup>             | maskable   | 0FFF0h              | 24              |
|  |   |  | 0FFEEh              | 23              |
|  |   |  | 0FFECCh             | 22              |
|  |   |  | 0FFEAh              | 21              |
|  |   |  | 0FFE8h              | 20              |
| I/O Port P2 (two flags)  | P2IFG.6 to P2IFG.7 <sup>(2)(4)</sup>              | maskable   | 0FFE6h              | 19              |
| I/O Port P1 (eight flags)  | P1IFG.0 to P1IFG.7 <sup>(2)(4)</sup>              | maskable   | 0FFE4h              | 18              |
|  |   |  | 0FFE2h              | 17              |
|  |   |  | 0FFE0h              | 16              |
| See <sup>(6)</sup>   |   |  | 0FFDEh to<br>0FFC0h | 15 to 0, lowest |

(1) A reset is generated if the CPU tries to fetch instructions from within the module register memory address range (0h to 01FFh) or from within unused address ranges.

(2) Multiple source flags

(3) (non)-maskable: the individual interrupt-enable bit can disable an interrupt event, but the general interrupt enable cannot.


(4) Interrupt flags are located in the module.

(5) Devices with Comparator\_A+ only





(6) The interrupt vectors at addresses 0FFDEh to 0FFC0h are not used in this device and can be used for regular program code if necessary.

### Special Function Registers (SFRs)

Most interrupt and module enable bits are collected into the lowest address space. Special function register bits not allocated to a functional purpose are not physically present in the device. Simple software access is provided with this arrangement.

- Legend**
- rw:** Bit can be read and written.
  - rw-0,1:** Bit can be read and written. It is reset or set by PUC.
  - rw-(0,1):** Bit can be read and written. It is reset or set by POR.
  -  SFR bit is not present in device.




**Table 6. Interrupt Enable Register 1 and 2**

| Address | 7   | 6   | 5      | 4     | 3  | 2   | 1    | 0     |
|---------|---|---|--------|-------|--|---|------|-------|
| 00h     |  |  | ACCVIE | NMIIE |  |  | OFIE | WDTIE |
|         |   |   | rw-0   | rw-0  |  |   | rw-0 | rw-0  |

- WDTIE** Watchdog Timer interrupt enable. Inactive if watchdog mode is selected. Active if Watchdog Timer is configured in interval timer mode.
- OFIE** Oscillator fault interrupt enable
- NMIIE** (Non)maskable interrupt enable
- ACCVIE** Flash access violation interrupt enable

| Address | 7   | 6   | 5   | 4   | 3  | 2   | 1   | 0   |
|---------|---|---|---|---|--|---|---|---|
| 01h     |  |  |  |  |  |  |  |  |

**Table 7. Interrupt Flag Register 1 and 2**

| Address | 7   | 6   | 5   | 4      | 3      | 2      | 1     | 0      |
|---------|---|---|---|--------|--------|--------|-------|--------|
| 02h     |  |  |  | NMIIFG | RSTIFG | PORIFG | OFIFG | WDTIFG |
|         |   |   |   | rw-0   | rw-(0) | rw-(1) | rw-1  | rw-(0) |

- WDTIFG** Set on watchdog timer overflow (in watchdog mode) or security key violation. Reset on V<sub>CC</sub> power-on or a reset condition at the RST/NMI pin in reset mode.
- OFIFG** Flag set on oscillator fault.
- PORIFG** Power-on reset interrupt flag. Set on V<sub>CC</sub> power-up.
- RSTIFG** External reset interrupt flag. Set on a reset condition at RST/NMI pin in reset mode. Reset on V<sub>CC</sub> power-up.
- NMIIFG** Set via RST/NMI pin

| Address | 7   | 6   | 5   | 4   | 3  | 2   | 1   | 0   |
|---------|---|---|---|---|--|---|---|---|
| 03h     |  |  |  |  |  |  |  |  |

## Memory Organization

**Table 8. Memory Organization**

|                        |           | <b>MSP430G2001<br/>MSP430G2011</b> | <b>MSP430G2101<br/>MSP430G2111</b> | <b>MSP430G2201<br/>MSP430G2211</b> |
|------------------------|-----------|------------------------------------|------------------------------------|------------------------------------|
| Memory                 | Size      | 512B                               | 1kB                                | 2kB                                |
| Main: interrupt vector | Flash     | 0xFFFF to 0xFFC0                   | 0xFFFF to 0xFFC0                   | 0xFFFF to 0xFFC0                   |
| Main: code memory      | Flash     | 0xFFFF to 0xFE00                   | 0xFFFF to 0xFC00                   | 0xFFFF to 0xF800                   |
| Information memory     | Size      | 256 Byte                           | 256 Byte                           | 256 Byte                           |
|                        | Flash     | 010FFh to 01000h                   | 010FFh to 01000h                   | 010FFh to 01000h                   |
| RAM                    | Size      | 128B                               | 128B                               | 128B                               |
|                        |           | 027Fh to 0200h                     | 027Fh to 0200h                     | 027Fh to 0200h                     |
| Peripherals            | 16-bit    | 01FFh to 0100h                     | 01FFh to 0100h                     | 01FFh to 0100h                     |
|                        | 8-bit     | 0FFh to 010h                       | 0FFh to 010h                       | 0FFh to 010h                       |
|                        | 8-bit SFR | 0Fh to 00h                         | 0Fh to 00h                         | 0Fh to 00h                         |

## Flash Memory

The flash memory can be programmed via the Spy-Bi-Wire or JTAG port or in-system by the CPU. The CPU can perform single-byte and single-word writes to the flash memory. Features of the flash memory include:

- Flash memory has n segments of main memory and four segments of information memory (A to D) of 64 bytes each. Each segment in main memory is 512 bytes in size.
- Segments 0 to n may be erased in one step, or each segment may be individually erased.
- Segments A to D can be erased individually or as a group with segments 0 to n. Segments A to D are also called *information memory*.
- Segment A contains calibration data. After reset segment A is protected against programming and erasing. It can be unlocked but care should be taken not to erase this segment if the device-specific calibration data is required.

## Peripherals

Peripherals are connected to the CPU through data, address, and control buses and can be handled using all instructions. For complete module descriptions, see the *MSP430x2xx Family User's Guide (SLAU144)*.

### Oscillator and System Clock

The clock system is supported by the basic clock module that includes support for a 32768-Hz watch crystal oscillator, an internal very-low-power low-frequency oscillator and an internal digitally controlled oscillator (DCO). The basic clock module is designed to meet the requirements of both low system cost and low power consumption. The internal DCO provides a fast turn-on clock source and stabilizes in less than 1  $\mu$ s. The basic clock module provides the following clock signals:

- Auxiliary clock (ACLK), sourced either from a 32768-Hz watch crystal or the internal LF oscillator.
- Main clock (MCLK), the system clock used by the CPU.
- Sub-Main clock (SMCLK), the sub-system clock used by the peripheral modules.

**Table 9. DCO Calibration Data**  
(Provided From Factory In Flash Information Memory Segment A)

| DCO FREQUENCY | CALIBRATION REGISTER | SIZE | ADDRESS |
|---------------|----------------------|------|---------|
| 1 MHz         | CALBC1_1MHZ          | byte | 010FFh  |
|               | CALDCO_1MHZ          | byte | 010FEh  |

### Brownout

The brownout circuit is implemented to provide the proper internal reset signal to the device during power on and power off.

### Digital I/O

There is one 8-bit I/O port implemented—port P1—and two bits of I/O port P2:

- All individual I/O bits are independently programmable.
- Any combination of input, output, and interrupt condition is possible.
- Edge-selectable interrupt input capability for all the eight bits of port P1 and the two bits of port P2.
- Read/write access to port-control registers is supported by all instructions.
- Each I/O has an individually programmable pullup/pulldown resistor.

### Watchdog Timer (WDT+)

The primary function of the watchdog timer (WDT+) module is to perform a controlled system restart after a software problem occurs. If the selected time interval expires, a system reset is generated. If the watchdog function is not needed in an application, the module can be disabled or configured as an interval timer and can generate interrupts at selected time intervals.

## Timer\_A2

Timer\_A2 is a 16-bit timer/counter with two capture/compare registers. Timer\_A2 can support multiple capture/compares, PWM outputs, and interval timing. Timer\_A2 also has extensive interrupt capabilities. Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.

**Table 10. Timer\_A2 Signal Connections - Devices With No Analog**

| INPUT PIN NUMBER |          | DEVICE INPUT SIGNAL | MODULE INPUT NAME | MODULE BLOCK | MODULE OUTPUT SIGNAL | OUTPUT PIN NUMBER |           |
|------------------|----------|---------------------|-------------------|--------------|----------------------|-------------------|-----------|
| PW, N            | RSA      |                     |                   |              |                      | PW, N             | RSA       |
| 2 - P1.0         | 1 - P1.0 | TACLK               | TACLK             | Timer        | NA                   |                   |           |
|                  |          | ACLK                | ACLK              |              |                      |                   |           |
|                  |          | SMCLK               | SMCLK             |              |                      |                   |           |
| 2 - P1.0         | 1 - P1.0 | TACLK               | INCLK             |              |                      |                   |           |
| 3 - P1.1         | 2 - P1.1 | TA0                 | CC10A             | CCR0         | TA0                  | 3 - P1.1          | 2 - P1.1  |
|                  |          | ACLK (internal)     | CC10B             |              |                      | 7 - P1.5          | 6 - P1.5  |
|                  |          | V <sub>SS</sub>     | GND               |              |                      |                   |           |
|                  |          | V <sub>CC</sub>     | V <sub>CC</sub>   |              |                      |                   |           |
| 4 - P1.2         | 3 - P1.2 | TA1                 | CC11A             | CCR1         | TA1                  | 4 - P1.2          | 3 - P1.2  |
|                  |          | TA1                 | CC11B             |              |                      | 8 - P1.6          | 7 - P1.6  |
|                  |          | V <sub>SS</sub>     | GND               |              |                      | 13 - P2.6         | 12 - P2.6 |
|                  |          | V <sub>CC</sub>     | V <sub>CC</sub>   |              |                      |                   |           |

**Table 11. Timer\_A2 Signal Connections - Devices With Comparator\_A+**

| INPUT PIN NUMBER |          | DEVICE INPUT SIGNAL | MODULE INPUT NAME | MODULE BLOCK | MODULE OUTPUT SIGNAL | OUTPUT PIN NUMBER |           |
|------------------|----------|---------------------|-------------------|--------------|----------------------|-------------------|-----------|
| PW, N            | RSA      |                     |                   |              |                      | PW, N             | RSA       |
| 2 - P1.0         | 1 - P1.0 | TACLK               | TACLK             | Timer        | NA                   |                   |           |
|                  |          | ACLK                | ACLK              |              |                      |                   |           |
|                  |          | SMCLK               | SMCLK             |              |                      |                   |           |
| 2 - P1.0         | 1 - P1.0 | TACLK               | INCLK             |              |                      |                   |           |
| 3 - P1.1         | 2 - P1.1 | TA0                 | CC10A             | CCR0         | TA0                  | 3 - P1.1          | 2 - P1.1  |
|                  |          | ACLK (internal)     | CC10B             |              |                      | 7 - P1.5          | 6 - P1.5  |
|                  |          | V <sub>SS</sub>     | GND               |              |                      |                   |           |
|                  |          | V <sub>CC</sub>     | V <sub>CC</sub>   |              |                      |                   |           |
| 4 - P1.2         | 3 - P1.2 | TA1                 | CC11A             | CCR1         | TA1                  | 4 - P1.2          | 3 - P1.2  |
|                  |          | CAOUT (internal)    | CC11B             |              |                      | 8 - P1.6          | 7 - P1.6  |
|                  |          | V <sub>SS</sub>     | GND               |              |                      | 13 - P2.6         | 12 - P2.6 |
|                  |          | V <sub>CC</sub>     | V <sub>CC</sub>   |              |                      |                   |           |

### Comparator\_A+ (MSP430G2x11 Only)

The primary function of the comparator\_A+ module is to support precision slope analog-to-digital conversions, battery-voltage supervision, and monitoring of external analog signals.

Peripheral File Map

**Table 12. Peripherals With Word Access**

| MODULE          | REGISTER DESCRIPTION     | REGISTER NAME | OFFSET |
|-----------------|--------------------------|---------------|--------|
| Timer_A         | Capture/compare register | TACCR1        | 0174h  |
|                 | Capture/compare register | TACCR0        | 0172h  |
|                 | Timer_A register         | TAR           | 0170h  |
|                 | Capture/compare control  | TACCTL1       | 0164h  |
|                 | Capture/compare control  | TACCTL0       | 0162h  |
|                 | Timer_A control          | TACTL         | 0160h  |
|                 | Timer_A interrupt vector | TAIV          | 012Eh  |
| Flash Memory    | Flash control 3          | FCTL3         | 012Ch  |
|                 | Flash control 2          | FCTL2         | 012Ah  |
|                 | Flash control 1          | FCTL1         | 0128h  |
| Watchdog Timer+ | Watchdog/timer control   | WDTCTL        | 0120h  |

**Table 13. Peripherals With Byte Access**

| MODULE                              | REGISTER DESCRIPTION          | REGISTER NAME | OFFSET |
|-------------------------------------|-------------------------------|---------------|--------|
| Comparator_A+<br>(MSP430G2x11 only) | Comparator_A+ port disable    | CAPD          | 05Bh   |
|                                     | Comparator_A+ control 2       | CACTL2        | 05Ah   |
|                                     | Comparator_A+ control 1       | CACTL1        | 059h   |
| Basic Clock System+                 | Basic clock system control 3  | BCSCTL3       | 053h   |
|                                     | Basic clock system control 2  | BCSCTL2       | 058h   |
|                                     | Basic clock system control 1  | BCSCTL1       | 057h   |
|                                     | DCO clock frequency control   | DCOCTL        | 056h   |
| Port P2                             | Port P2 resistor enable       | P2REN         | 02Fh   |
|                                     | Port P2 selection             | P2SEL         | 02Eh   |
|                                     | Port P2 interrupt enable      | P2IE          | 02Dh   |
|                                     | Port P2 interrupt edge select | P2IES         | 02Ch   |
|                                     | Port P2 interrupt flag        | P2IFG         | 02Bh   |
|                                     | Port P2 direction             | P2DIR         | 02Ah   |
|                                     | Port P2 output                | P2OUT         | 029h   |
| Port P2 input                       | P2IN                          | 028h          |        |
| Port P1                             | Port P1 resistor enable       | P1REN         | 027h   |
|                                     | Port P1 selection             | P1SEL         | 026h   |
|                                     | Port P1 interrupt enable      | P1IE          | 025h   |
|                                     | Port P1 interrupt edge select | P1IES         | 024h   |
|                                     | Port P1 interrupt flag        | P1IFG         | 023h   |
|                                     | Port P1 direction             | P1DIR         | 022h   |
|                                     | Port P1 output                | P1OUT         | 021h   |
| Port P1 input                       | P1IN                          | 020h          |        |
| Special Function                    | SFR interrupt flag 2          | IFG2          | 003h   |
|                                     | SFR interrupt flag 1          | IFG1          | 002h   |
|                                     | SFR interrupt enable 2        | IE2           | 001h   |
|                                     | SFR interrupt enable 1        | IE1           | 000h   |

### Absolute Maximum Ratings<sup>(1)</sup>

|  |                     |                                   |
|--|---------------------|-----------------------------------|
| Voltage applied at V <sub>CC</sub> to V <sub>SS</sub>      |                     | -0.3 V to 4.1 V                   |
| Voltage applied to any pin <sup>(2)</sup>                  |                     | -0.3 V to V <sub>CC</sub> + 0.3 V |
| Diode current at any device pin                            |                     | ±2 mA                             |
| Storage temperature range, T <sub>stg</sub> <sup>(3)</sup> | Unprogrammed device | -55°C to 150°C                    |
|  | Programmed device   | -55°C to 150°C                    |

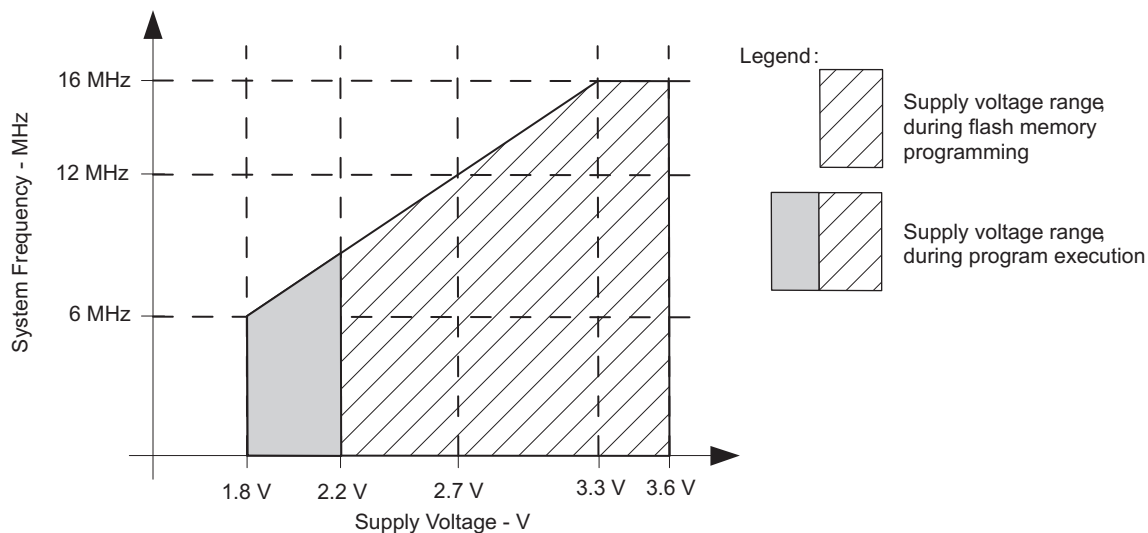
- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages referenced to V<sub>SS</sub>. The JTAG fuse-blow voltage, V<sub>FB</sub>, is allowed to exceed the absolute maximum rating. The voltage is applied to the TEST pin when blowing the JTAG fuse.
- (3) Higher temperature may be applied during board soldering according to the current JEDEC J-STD-020 specification with peak reflow temperatures not higher than classified on the device label on the shipping boxes or reels.

### Recommended Operating Conditions

Typical values are specified at V<sub>CC</sub> = 3.3 V and T<sub>A</sub> = 25°C (unless otherwise noted)

|                     |  | MIN  | NOM | MAX | UNIT |     |
|---------------------|--|--|-----|-----|------|-----|
| V <sub>CC</sub>     | Supply voltage   | During program execution                           |     | 1.8 | 3.6  | V   |
|                     |  | During flash program or erase                      |     | 2.2 | 3.6  |     |
| V <sub>SS</sub>     | Supply voltage   |  |     | 0   | V    |     |
| T <sub>A</sub>      | Operating free-air temperature                                 | -40  |     | 85  | °C   |     |
| f <sub>SYSTEM</sub> | Processor frequency (maximum MCLK frequency) <sup>(1)(2)</sup> | V <sub>CC</sub> = 1.8 V,<br>Duty cycle = 50% ± 10% |     | dc  | 6    | MHz |
|                     |  | V <sub>CC</sub> = 2.7 V,<br>Duty cycle = 50% ± 10% |     | dc  | 12   |     |
|                     |  | V <sub>CC</sub> ≥ 3.3 V,<br>Duty cycle = 50% ± 10% |     | dc  | 16   |     |

- (1) The MSP430 CPU is clocked directly with MCLK. Both the high and low phase of MCLK must not exceed the pulse duration of the specified maximum frequency.
- (2) Modules might have a different maximum input clock specification. See the specification of the respective module in this data sheet.



Note: Minimum processor frequency is defined by system clock. Flash program or erase operations require a minimum V<sub>CC</sub> of 2.2 V.

Figure 1. Safe Operating Area

## Electrical Characteristics

### Active Mode Supply Current Into $V_{CC}$ Excluding External Current

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)(2)</sup>

| PARAMETER                                      | TEST CONDITIONS   | $V_{CC}$ | MIN | TYP | MAX | UNIT    |
|--|---|----------|-----|-----|-----|---------|
| $I_{AM,1MHz}$ Active mode (AM) current (1 MHz) | $f_{DCO} = f_{MCLK} = f_{SMCLK} = 1$ MHz,<br>$f_{ACLK} = 32768$ Hz,<br>Program executes in flash,<br>BCSCTL1 = CALBC1_1MHZ,<br>DCOCTL = CALDCO_1MHZ,<br>CPUOFF = 0, SCG0 = 0, SCG1 = 0,<br>OSCOFF = 0 | 2.2 V    |     | 220 |     | $\mu A$ |
|  |   | 3 V      |     | 300 | 370 |         |

- (1) All inputs are tied to 0 V or to  $V_{CC}$ . Outputs do not source or sink any current.
- (2) The currents are characterized with a Micro Crystal CC4V-T1A SMD crystal with a load capacitance of 9 pF. The internal and external load capacitance is chosen to closely match the required 9 pF.

### Typical Characteristics - Active Mode Supply Current (Into $V_{CC}$ )

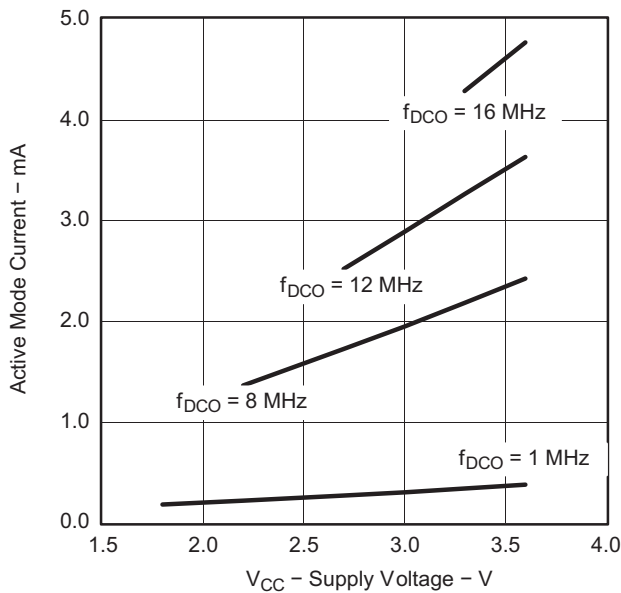


Figure 2. Active Mode Current vs  $V_{CC}$ ,  $T_A = 25^\circ C$

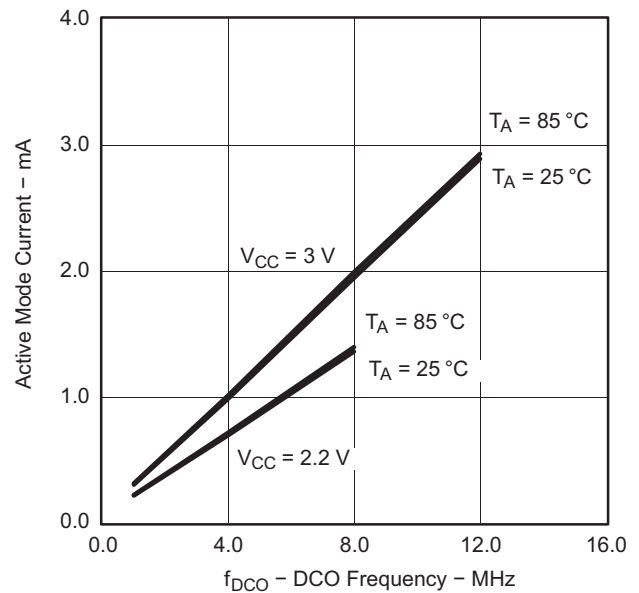


Figure 3. Active Mode Current vs DCO Frequency

### Low-Power Mode Supply Currents (Into $V_{CC}$ ) Excluding External Current

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1) (2)</sup>

| PARAMETER   | TEST CONDITIONS   | $T_A$ | $V_{CC}$ | MIN | TYP | MAX | UNIT    |
|---|---|-------|----------|-----|-----|-----|---------|
| $I_{LPM0,1MHz}$ Low-power mode 0 (LPM0) current <sup>(3)</sup>  | $f_{MCLK} = 0$ MHz,<br>$f_{SMCLK} = f_{DCO} = 1$ MHz,<br>$f_{ACLK} = 32768$ Hz,<br>BCSCTL1 = CALBC1_1MHZ,<br>DCOCTL = CALDCO_1MHZ,<br>CPUOFF = 1, SCG0 = 0, SCG1 = 0,<br>OSCOFF = 0 | 25°C  | 2.2 V    |     | 65  |     | $\mu$ A |
| $I_{LPM2}$ Low-power mode 2 (LPM2) current <sup>(4)</sup>       | $f_{MCLK} = f_{SMCLK} = 0$ MHz,<br>$f_{DCO} = 1$ MHz,<br>$f_{ACLK} = 32768$ Hz,<br>BCSCTL1 = CALBC1_1MHZ,<br>DCOCTL = CALDCO_1MHZ,<br>CPUOFF = 1, SCG0 = 0, SCG1 = 1,<br>OSCOFF = 0 | 25°C  | 2.2 V    |     | 22  |     | $\mu$ A |
| $I_{LPM3,LFXT1}$ Low-power mode 3 (LPM3) current <sup>(4)</sup> | $f_{DCO} = f_{MCLK} = f_{SMCLK} = 0$ MHz,<br>$f_{ACLK} = 32768$ Hz,<br>CPUOFF = 1, SCG0 = 1, SCG1 = 1,<br>OSCOFF = 0  | 25°C  | 2.2 V    |     | 0.7 | 1.5 | $\mu$ A |
| $I_{LPM3,VLO}$ Low-power mode 3 current, (LPM3) <sup>(4)</sup>  | $f_{DCO} = f_{MCLK} = f_{SMCLK} = 0$ MHz,<br>$f_{ACLK}$ from internal LF oscillator (VLO),<br>CPUOFF = 1, SCG0 = 1, SCG1 = 1,<br>OSCOFF = 0   | 25°C  | 2.2 V    |     | 0.5 | 0.7 | $\mu$ A |
| $I_{LPM4}$ Low-power mode 4 (LPM4) current <sup>(5)</sup>       | $f_{DCO} = f_{MCLK} = f_{SMCLK} = 0$ MHz,<br>$f_{ACLK} = 0$ Hz,<br>CPUOFF = 1, SCG0 = 1, SCG1 = 1,<br>OSCOFF = 1  | 25°C  | 2.2 V    |     | 0.1 | 0.5 | $\mu$ A |
|   |   | 85°C  |          |     | 0.8 | 1.5 |         |

- (1) All inputs are tied to 0 V or to  $V_{CC}$ . Outputs do not source or sink any current.
- (2) The currents are characterized with a Micro Crystal CC4V-T1A SMD crystal with a load capacitance of 9 pF.
- (3) Current for brownout and WDT clocked by SMCLK included.
- (4) Current for brownout and WDT clocked by ACLK included.
- (5) Current for brownout included.

### Typical Characteristics Low-Power Mode Supply Currents

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

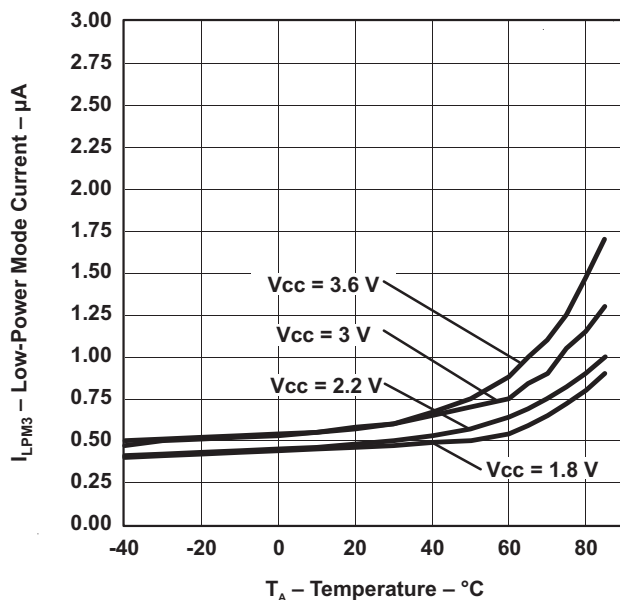


Figure 4. LPM3 Current vs Temperature

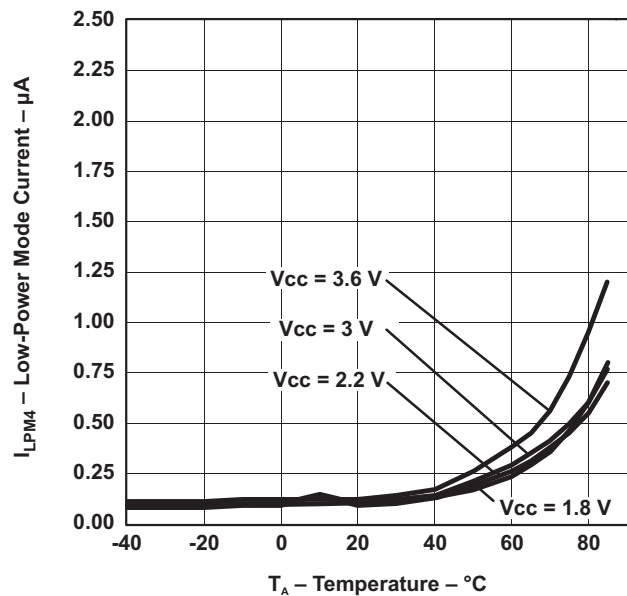


Figure 5. LPM4 Current vs Temperature

### Schmitt-Trigger Inputs - Ports Px

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER         |   | TEST CONDITIONS  | V <sub>CC</sub> | MIN                  | TYP | MAX                  | UNIT |
|-------------------|---|--|-----------------|----------------------|-----|----------------------|------|
| V <sub>IT+</sub>  | Positive-going input threshold voltage                          |  |                 | 0.45 V <sub>CC</sub> |     | 0.75 V <sub>CC</sub> | V    |
|                   |   |  | 3 V             | 1.35                 |     | 2.25                 |      |
| V <sub>IT-</sub>  | Negative-going input threshold voltage                          |  |                 | 0.25 V <sub>CC</sub> |     | 0.55 V <sub>CC</sub> | V    |
|                   |   |  | 3 V             | 0.75                 |     | 1.65                 |      |
| V <sub>hys</sub>  | Input voltage hysteresis (V <sub>IT+</sub> - V <sub>IT-</sub> ) |  | 3 V             | 0.3                  |     | 1                    | V    |
| R <sub>Pull</sub> | Pullup/pulldown resistor  | For pullup: V <sub>IN</sub> = V <sub>SS</sub><br>For pulldown: V <sub>IN</sub> = V <sub>CC</sub> | 3 V             | 20                   | 35  | 50                   | kΩ   |
| C <sub>I</sub>    | Input capacitance   | V <sub>IN</sub> = V <sub>SS</sub> or V <sub>CC</sub>   |                 |                      | 5   |                      | pF   |

### Leakage Current - Ports Px

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER              |                                | TEST CONDITIONS | V <sub>CC</sub> | MIN | MAX | UNIT |
|------------------------|--------------------------------|-----------------|-----------------|-----|-----|------|
| I <sub>lkg(Px.y)</sub> | High-impedance leakage current | (1) (2)         | 3 V             |     | ±50 | nA   |

- (1) The leakage current is measured with V<sub>SS</sub> or V<sub>CC</sub> applied to the corresponding pin(s), unless otherwise noted.
- (2) The leakage of the digital port pins is measured individually. The port pin is selected for input and the pullup/pulldown resistor is disabled.

### Outputs - Ports Px

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER       |                           | TEST CONDITIONS                             | V <sub>CC</sub> | MIN | TYP                   | MAX | UNIT |
|-----------------|---------------------------|---|-----------------|-----|-----------------------|-----|------|
| V <sub>OH</sub> | High-level output voltage | I <sub>(OHmax)</sub> = -6 mA <sup>(1)</sup> | 3 V             |     | V <sub>CC</sub> - 0.3 |     | V    |
| V <sub>OL</sub> | Low-level output voltage  | I <sub>(OLmax)</sub> = 6 mA <sup>(1)</sup>  | 3 V             |     | V <sub>SS</sub> + 0.3 |     | V    |

- (1) The maximum total current, I<sub>(OHmax)</sub> and I<sub>(OLmax)</sub>, for all outputs combined should not exceed ±48 mA to hold the maximum voltage drop specified.

### Output Frequency - Ports Px

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER             |                                   | TEST CONDITIONS  | V <sub>CC</sub> | MIN | TYP | MAX | UNIT |
|-----------------------|-----------------------------------|--|-----------------|-----|-----|-----|------|
| f <sub>Px.y</sub>     | Port output frequency (with load) | Px.y, C <sub>L</sub> = 20 pF, R <sub>L</sub> = 1 kΩ <sup>(1)</sup> (2) | 3 V             |     | 12  |     | MHz  |
| f <sub>Port_CLK</sub> | Clock output frequency            | Px.y, C <sub>L</sub> = 20 pF <sup>(2)</sup>                            | 3 V             |     | 16  |     | MHz  |

- (1) A resistive divider with 2 × 0.5 kΩ between V<sub>CC</sub> and V<sub>SS</sub> is used as load. The output is connected to the center tap of the divider.
- (2) The output voltage reaches at least 10% and 90% V<sub>CC</sub> at the specified toggle frequency.

### Typical Characteristics - Outputs

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

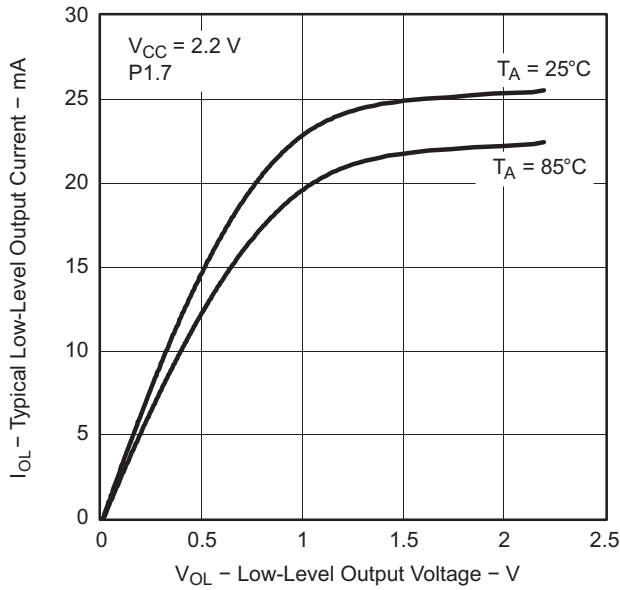


Figure 6.

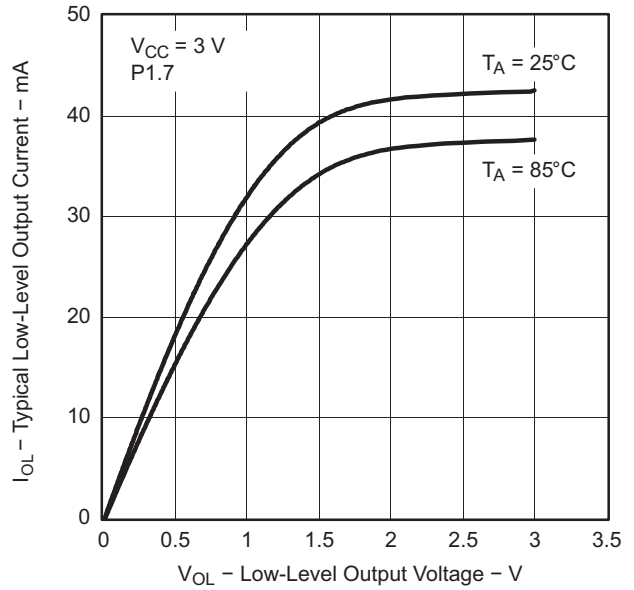


Figure 7.

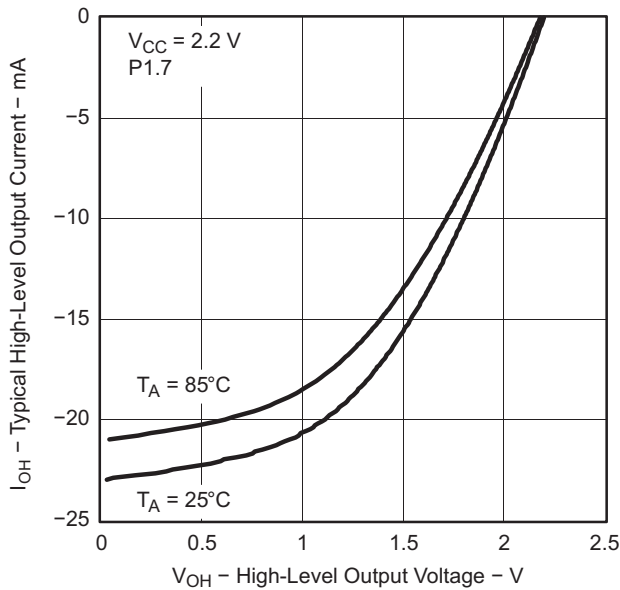


Figure 8.

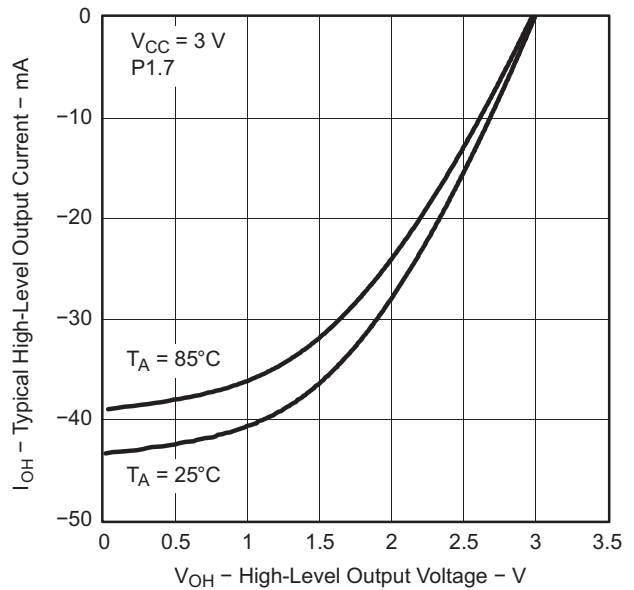


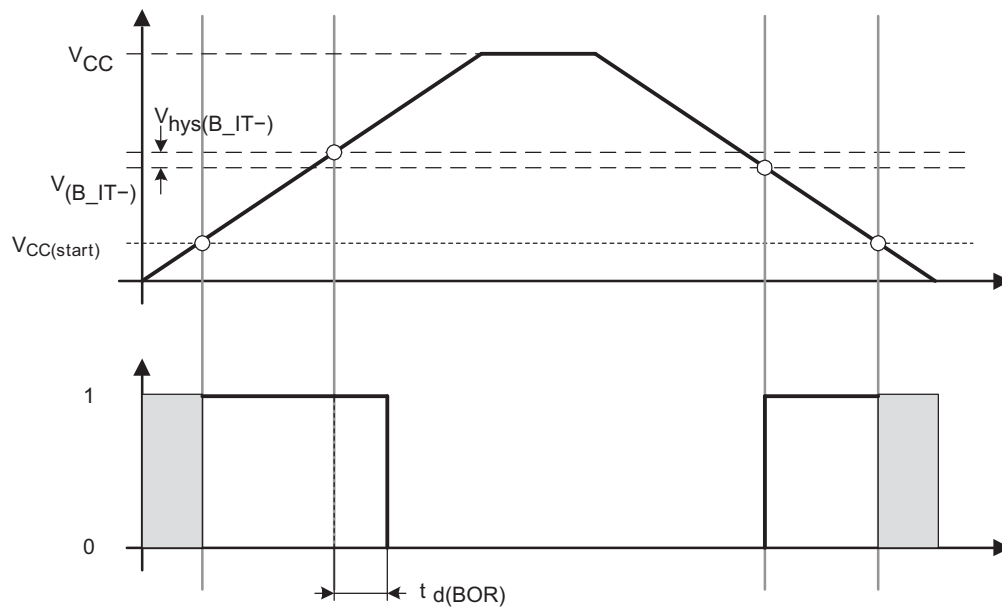
Figure 9.

**POR, BOR (1)(2)**

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER               |  | TEST CONDITIONS              | V <sub>CC</sub> | MIN | TYP                        | MAX  | UNIT |
|-------------------------|--|------------------------------|-----------------|-----|----------------------------|------|------|
| V <sub>CC(start)</sub>  | See Figure 10  | dV <sub>CC</sub> /dt ≤ 3 V/s |                 |     | 0.7 × V <sub>(B_IT-)</sub> |      | V    |
| V <sub>(B_IT-)</sub>    | See Figure 10 through Figure 12  | dV <sub>CC</sub> /dt ≤ 3 V/s |                 |     | 1.35                       |      | V    |
| V <sub>hys(B_IT-)</sub> | See Figure 10  | dV <sub>CC</sub> /dt ≤ 3 V/s |                 |     | 130                        |      | mV   |
| t <sub>d(BOR)</sub>     | See Figure 10  |                              |                 |     |                            | 2000 | μs   |
| t <sub>(reset)</sub>    | Pulse duration needed at $\overline{\text{RST}}/\text{NMI}$ pin to accepted reset internally |                              | 2.2 V, 3 V      | 2   |                            |      | μs   |

- (1) The current consumption of the brownout module is already included in the I<sub>CC</sub> current consumption data. The voltage level V<sub>(B\_IT-)</sub> + V<sub>hys(B\_IT-)</sub> is ≤ 1.8 V.
- (2) During power up, the CPU begins code execution following a period of t<sub>d(BOR)</sub> after V<sub>CC</sub> = V<sub>(B\_IT-)</sub> + V<sub>hys(B\_IT-)</sub>. The default DCO settings must not be changed until V<sub>CC</sub> ≥ V<sub>CC(min)</sub>, where V<sub>CC(min)</sub> is the minimum supply voltage for the desired operating frequency.



**Figure 10. POR and BOR vs Supply Voltage**

Typical Characteristics - POR and BOR

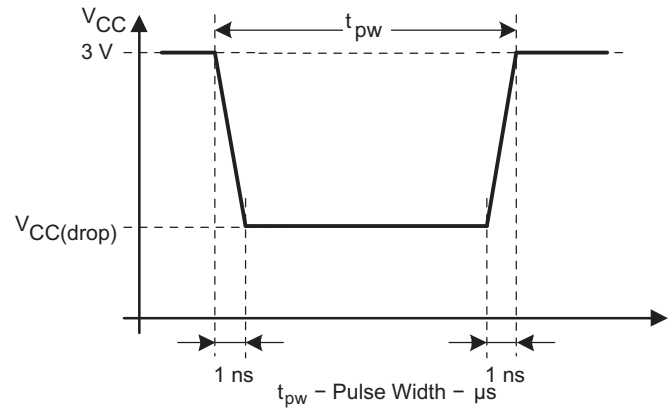
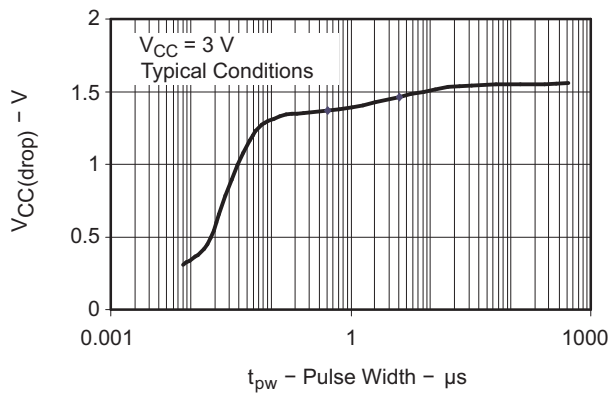


Figure 11.  $V_{CC(drop)}$  Level With a Square Voltage Drop to Generate a POR or BOR Signal

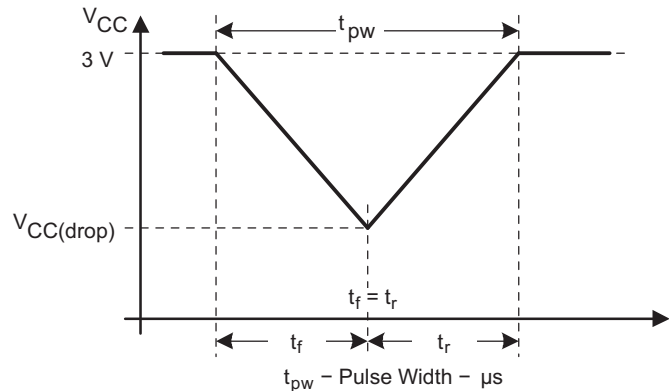
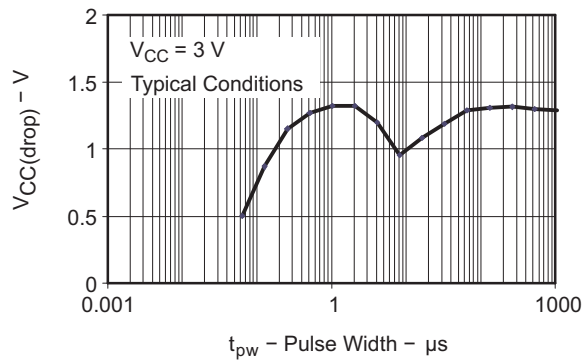


Figure 12.  $V_{CC(drop)}$  Level With a Triangle Voltage Drop to Generate a POR or BOR Signal

## Main DCO Characteristics

- All ranges selected by RSELx overlap with RSELx + 1: RSELx = 0 overlaps RSELx = 1, ... RSELx = 14 overlaps RSELx = 15.
- DCO control bits DCOx have a step size as defined by parameter S<sub>DCO</sub>.
- Modulation control bits MODx select how often f<sub>DCO(RSEL,DCO+1)</sub> is used within the period of 32 DCOCLK cycles. The frequency f<sub>DCO(RSEL,DCO)</sub> is used for the remaining cycles. The frequency is an average equal to:

$$f_{\text{average}} = \frac{32 \times f_{\text{DCO(RSEL,DCO)}} \times f_{\text{DCO(RSEL,DCO+1)}}}{\text{MOD} \times f_{\text{DCO(RSEL,DCO)}} + (32 - \text{MOD}) \times f_{\text{DCO(RSEL,DCO+1)}}}$$

## DCO Frequency

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER              |  | TEST CONDITIONS  | V <sub>CC</sub> | MIN  | TYP   | MAX  | UNIT  |
|------------------------|--|--|-----------------|------|-------|------|-------|
| V <sub>CC</sub>        | Supply voltage                               | RSELx < 14   |                 | 1.8  |       | 3.6  | V     |
|                        |  | RSELx = 14   |                 | 2.2  |       | 3.6  | V     |
|                        |  | RSELx = 15   |                 | 3    |       | 3.6  | V     |
| f <sub>DCO(0,0)</sub>  | DCO frequency (0, 0)                         | RSELx = 0, DCOx = 0, MODx = 0  | 3 V             | 0.06 |       | 0.14 | MHz   |
| f <sub>DCO(0,3)</sub>  | DCO frequency (0, 3)                         | RSELx = 0, DCOx = 3, MODx = 0  | 3 V             |      | 0.12  |      | MHz   |
| f <sub>DCO(1,3)</sub>  | DCO frequency (1, 3)                         | RSELx = 1, DCOx = 3, MODx = 0  | 3 V             |      | 0.15  |      | MHz   |
| f <sub>DCO(2,3)</sub>  | DCO frequency (2, 3)                         | RSELx = 2, DCOx = 3, MODx = 0  | 3 V             |      | 0.21  |      | MHz   |
| f <sub>DCO(3,3)</sub>  | DCO frequency (3, 3)                         | RSELx = 3, DCOx = 3, MODx = 0  | 3 V             |      | 0.3   |      | MHz   |
| f <sub>DCO(4,3)</sub>  | DCO frequency (4, 3)                         | RSELx = 4, DCOx = 3, MODx = 0  | 3 V             |      | 0.41  |      | MHz   |
| f <sub>DCO(5,3)</sub>  | DCO frequency (5, 3)                         | RSELx = 5, DCOx = 3, MODx = 0  | 3 V             |      | 0.58  |      | MHz   |
| f <sub>DCO(6,3)</sub>  | DCO frequency (6, 3)                         | RSELx = 6, DCOx = 3, MODx = 0  | 3 V             |      | 0.8   |      | MHz   |
| f <sub>DCO(7,3)</sub>  | DCO frequency (7, 3)                         | RSELx = 7, DCOx = 3, MODx = 0  | 3 V             | 0.8  |       | 1.5  | MHz   |
| f <sub>DCO(8,3)</sub>  | DCO frequency (8, 3)                         | RSELx = 8, DCOx = 3, MODx = 0  | 3 V             |      | 1.6   |      | MHz   |
| f <sub>DCO(9,3)</sub>  | DCO frequency (9, 3)                         | RSELx = 9, DCOx = 3, MODx = 0  | 3 V             |      | 2.3   |      | MHz   |
| f <sub>DCO(10,3)</sub> | DCO frequency (10, 3)                        | RSELx = 10, DCOx = 3, MODx = 0   | 3 V             |      | 3.4   |      | MHz   |
| f <sub>DCO(11,3)</sub> | DCO frequency (11, 3)                        | RSELx = 11, DCOx = 3, MODx = 0   | 3 V             |      | 4.25  |      | MHz   |
| f <sub>DCO(12,3)</sub> | DCO frequency (12, 3)                        | RSELx = 12, DCOx = 3, MODx = 0   | 3 V             | 4.3  |       | 7.3  | MHz   |
| f <sub>DCO(13,3)</sub> | DCO frequency (13, 3)                        | RSELx = 13, DCOx = 3, MODx = 0   | 3 V             |      | 7.8   |      | MHz   |
| f <sub>DCO(14,3)</sub> | DCO frequency (14, 3)                        | RSELx = 14, DCOx = 3, MODx = 0   | 3 V             | 8.6  |       | 13.9 | MHz   |
| f <sub>DCO(15,3)</sub> | DCO frequency (15, 3)                        | RSELx = 15, DCOx = 3, MODx = 0   | 3 V             |      | 15.25 |      | MHz   |
| f <sub>DCO(15,7)</sub> | DCO frequency (15, 7)                        | RSELx = 15, DCOx = 7, MODx = 0   | 3 V             |      | 21    |      | MHz   |
| S <sub>RSEL</sub>      | Frequency step between range RSEL and RSEL+1 | S <sub>RSEL</sub> = f <sub>DCO(RSEL+1,DCO)</sub> /f <sub>DCO(RSEL,DCO)</sub> | 3 V             |      | 1.35  |      | ratio |
| S <sub>DCO</sub>       | Frequency step between tap DCO and DCO+1     | S <sub>DCO</sub> = f <sub>DCO(RSEL,DCO+1)</sub> /f <sub>DCO(RSEL,DCO)</sub>  | 3 V             |      | 1.08  |      | ratio |
|                        | Duty cycle                                   | Measured at SMCLK output   | 3 V             |      | 50    |      | %     |

### Calibrated DCO Frequencies - Tolerance

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                                       | TEST CONDITIONS  | T <sub>A</sub> | V <sub>CC</sub> | MIN | TYP  | MAX | UNIT |
|---|--|----------------|-----------------|-----|------|-----|------|
| 1-MHz tolerance over temperature <sup>(1)</sup> | BCSCTL1= CALBC1_1MHz,<br>DCOCTL = CALDCO_1MHz,<br>calibrated at 30°C and 3 V | 0°C to 85°C    | 3 V             | -3  | ±0.5 | +3  | %    |
| 1-MHz tolerance over V <sub>CC</sub>            | BCSCTL1= CALBC1_1MHz,<br>DCOCTL = CALDCO_1MHz,<br>calibrated at 30°C and 3 V | 30°C           | 1.8 V to 3.6 V  | -3  | ±2   | +3  | %    |
| 1-MHz tolerance overall                         | BCSCTL1= CALBC1_1MHz,<br>DCOCTL = CALDCO_1MHz,<br>calibrated at 30°C and 3 V | -40°C to 85°C  | 1.8 V to 3.6 V  | -6  | ±3   | +6  | %    |

(1) This is the frequency change from the measured frequency at 30°C over temperature.

### Wake-Up From Lower-Power Modes (LPM3 or LPM4) Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER  | TEST CONDITIONS                               | V <sub>CC</sub> | MIN | TYP  | MAX | UNIT |
|--|---|-----------------|-----|--|-----|------|
| t <sub>DCO,LPM3/4</sub><br>DCO clock wake-up time from LPM3 or LPM4 <sup>(1)</sup> | BCSCTL1= CALBC1_1MHz,<br>DCOCTL = CALDCO_1MHz | 3 V             |     | 1.5  |     | µs   |
| t <sub>CPU,LPM3/4</sub><br>CPU wake-up time from LPM3 or LPM4 <sup>(2)</sup>       |   |                 |     | 1/f <sub>MCLK</sub> +<br>t <sub>Clock,LPM3/4</sub> |     |      |

(1) The DCO clock wake-up time is measured from the edge of an external wake-up signal (for example, port interrupt) to the first clock edge observable externally on a clock pin (MCLK or SMCLK).

(2) Parameter applicable only if DCOCLK is used for MCLK.

### Typical Characteristics - DCO Clock Wake-Up Time From LPM3 or LPM4

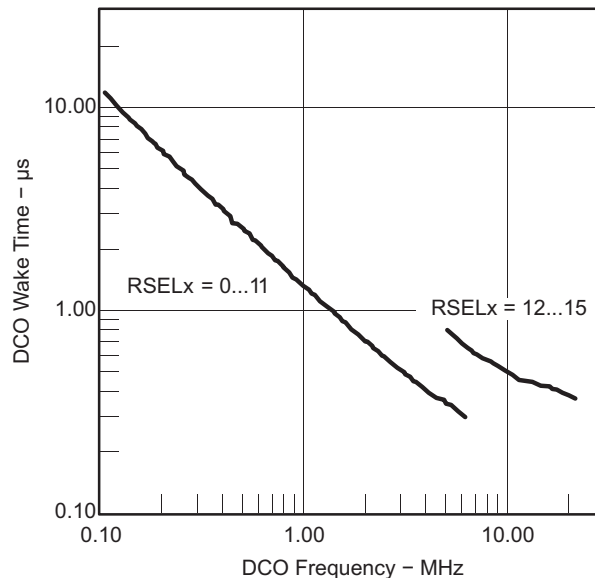


Figure 13. DCO Wake-Up Time From LPM3 vs DCO Frequency

### Crystal Oscillator, XT1, Low-Frequency Mode<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                   |   | TEST CONDITIONS  | V <sub>CC</sub> | MIN   | TYP   | MAX   | UNIT |
|-----------------------------|---|--|-----------------|-------|-------|-------|------|
| f <sub>LFXT1,LF</sub>       | LFXT1 oscillator crystal frequency, LF mode 0, 1                  | XTS = 0, LFXT1Sx = 0 or 1  | 1.8 V to 3.6 V  |       | 32768 |       | Hz   |
| f <sub>LFXT1,LF,logic</sub> | LFXT1 oscillator logic level square wave input frequency, LF mode | XTS = 0, XCAPx = 0, LFXT1Sx = 3  | 1.8 V to 3.6 V  | 10000 | 32768 | 50000 | Hz   |
| O <sub>A,LF</sub>           | Oscillation allowance for LF crystals                             | XTS = 0, LFXT1Sx = 0, f <sub>LFXT1,LF</sub> = 32768 Hz, C <sub>L,eff</sub> = 6 pF  |                 |       | 500   |       | kΩ   |
|                             |   | XTS = 0, LFXT1Sx = 0, f <sub>LFXT1,LF</sub> = 32768 Hz, C <sub>L,eff</sub> = 12 pF |                 |       | 200   |       |      |
| C <sub>L,eff</sub>          | Integrated effective load capacitance, LF mode <sup>(2)</sup>     | XTS = 0, XCAPx = 0   |                 |       | 1     |       | pF   |
|                             |   | XTS = 0, XCAPx = 1   |                 |       | 5.5   |       |      |
|                             |   | XTS = 0, XCAPx = 2   |                 |       | 8.5   |       |      |
|                             |   | XTS = 0, XCAPx = 3   |                 |       | 11    |       |      |
|                             | Duty cycle, LF mode   | XTS = 0, Measured at ACLK, f <sub>LFXT1,LF</sub> = 32768 Hz                        | 2.2 V           | 30    | 50    | 70    | %    |
| f <sub>Fault,LF</sub>       | Oscillator fault frequency, LF mode <sup>(3)</sup>                | XTS = 0, XCAPx = 0, LFXT1Sx = 3 <sup>(4)</sup>                                     | 2.2 V           | 10    |       | 10000 | Hz   |

- (1) To improve EMI on the XT1 oscillator, the following guidelines should be observed.
  - (a) Keep the trace between the device and the crystal as short as possible.
  - (b) Design a good ground plane around the oscillator pins.
  - (c) Prevent crosstalk from other clock or data lines into oscillator pins XIN and XOUT.
  - (d) Avoid running PCB traces underneath or adjacent to the XIN and XOUT pins.
  - (e) Use assembly materials and praxis to avoid any parasitic load on the oscillator XIN and XOUT pins.
  - (f) If conformal coating is used, ensure that it does not induce capacitive or resistive leakage between the oscillator pins.
  - (g) Do not route the XOUT line to the JTAG header to support the serial programming adapter as shown in other documentation. This signal is no longer required for the serial programming adapter.
- (2) Includes parasitic bond and package capacitance (approximately 2 pF per pin).  
Since the PCB adds additional capacitance, it is recommended to verify the correct load by measuring the ACLK frequency. For a correct setup, the effective load capacitance should always match the specification of the used crystal.
- (3) Frequencies below the MIN specification set the fault flag. Frequencies above the MAX specification do not set the fault flag. Frequencies in between might set the flag.
- (4) Measured with logic-level input frequency but also applies to operation with crystals.

### Internal Very-Low-Power Low-Frequency Oscillator (VLO)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                           |                                    | T <sub>A</sub> | V <sub>CC</sub> | MIN | TYP | MAX | UNIT |
|-------------------------------------|------------------------------------|----------------|-----------------|-----|-----|-----|------|
| f <sub>VLO</sub>                    | VLO frequency                      | -40°C to 85°C  | 3 V             | 4   | 12  | 20  | kHz  |
| df <sub>VLO</sub> /dT               | VLO frequency temperature drift    | -40°C to 85°C  | 3 V             |     | 0.5 |     | %/°C |
| df <sub>VLO</sub> /dV <sub>CC</sub> | VLO frequency supply voltage drift | 25°C           | 1.8 V to 3.6 V  |     | 4   |     | %/V  |

### Timer\_A

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER           |                               | TEST CONDITIONS   | V <sub>CC</sub> | MIN | TYP                 | MAX | UNIT |
|---------------------|-------------------------------|---|-----------------|-----|---------------------|-----|------|
| f <sub>TA</sub>     | Timer_A input clock frequency | Internal: SMCLK or ACLK, External: TACLK or INCLK, Duty cycle = 50% ± 10% |                 |     | f <sub>SYSTEM</sub> |     | MHz  |
| t <sub>TA,cap</sub> | Timer_A capture timing        | TA0, TA1  | 3 V             | 20  |                     |     | ns   |

## Comparator\_A+ (MSP430G2x11 only)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                         |   | TEST CONDITIONS   | V <sub>CC</sub> | MIN | TYP  | MAX                | UNIT |
|-----------------------------------|---|---|-----------------|-----|------|--------------------|------|
| I <sub>(DD)</sub>                 |   | CAON = 1, CARSEL = 0, CAREF = 0                                       | 3 V             |     | 45   |                    | μA   |
| I <sub>(Refladder/RefDiode)</sub> |   | CAON = 1, CARSEL = 0, CAREF = 1, 2, or 3,<br>No load at CA0 and CA1   | 3 V             |     | 45   |                    | μA   |
| V <sub>(IC)</sub>                 | Common-mode input voltage                                   | CAON = 1  | 3 V             | 0   |      | V <sub>CC</sub> -1 | V    |
| V <sub>(Ref025)</sub>             | $\frac{\text{Voltage @ } 0.25 V_{CC} \text{ node}}{V_{CC}}$ | PCA0 = 1, CARSEL = 1, CAREF = 1,<br>No load at CA0 and CA1            | 3 V             |     | 0.24 |                    |      |
| V <sub>(Ref050)</sub>             | $\frac{\text{Voltage @ } 0.5 V_{CC} \text{ node}}{V_{CC}}$  | PCA0 = 1, CARSEL = 1, CAREF = 2,<br>No load at CA0 and CA1            | 3 V             |     | 0.48 |                    |      |
| V <sub>(RefVT)</sub>              | See <a href="#">Figure 14</a> and <a href="#">Figure 15</a> | PCA0 = 1, CARSEL = 1, CAREF = 3,<br>No load at CA0 and CA1, TA = 85°C | 3 V             |     | 490  |                    | mV   |
| V <sub>(offset)</sub>             | Offset voltage <sup>(1)</sup>                               |   | 3 V             |     | ±10  |                    | mV   |
| V <sub>(hys)</sub>                | Input hysteresis  | CAON = 1  | 3 V             |     | 0.7  |                    | mV   |
| t <sub>(response)</sub>           | Response time<br>(low-high and high-low)                    | T <sub>A</sub> = 25°C, Overdrive 10 mV,<br>Without filter: CAF = 0    | 3 V             |     | 120  |                    | ns   |
|                                   |   | T <sub>A</sub> = 25°C, Overdrive 10 mV,<br>With filter: CAF = 1       |                 |     | 1.5  |                    | μs   |

- (1) The input offset voltage can be cancelled by using the CAEX bit to invert the Comparator\_A+ inputs on successive measurements. The two successive measurements are then summed together.

Typical Characteristics - Comparator\_A+

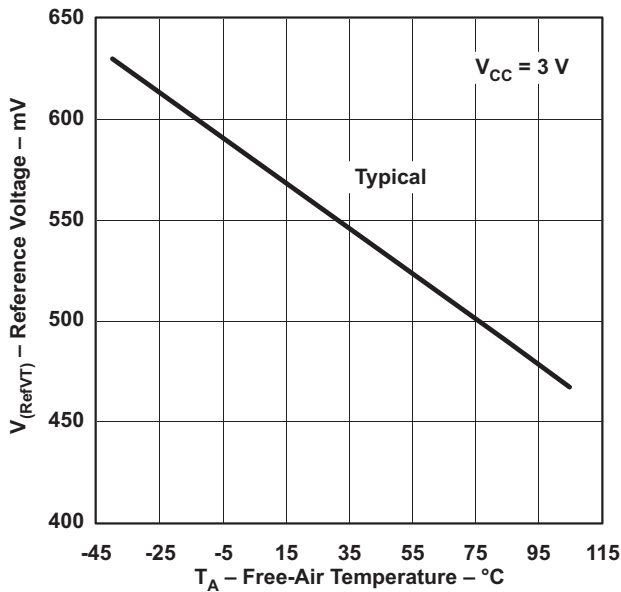


Figure 14.  $V_{(RefVT)}$  vs Temperature,  $V_{CC} = 3\text{ V}$

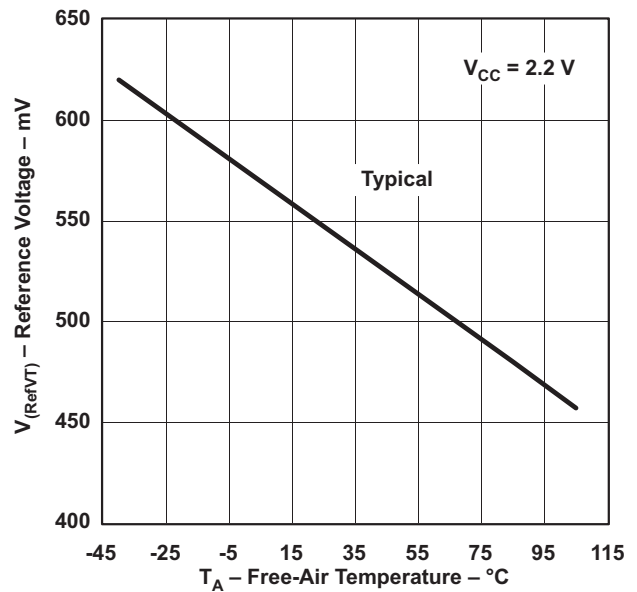


Figure 15.  $V_{(RefVT)}$  vs Temperature,  $V_{CC} = 2.2\text{ V}$

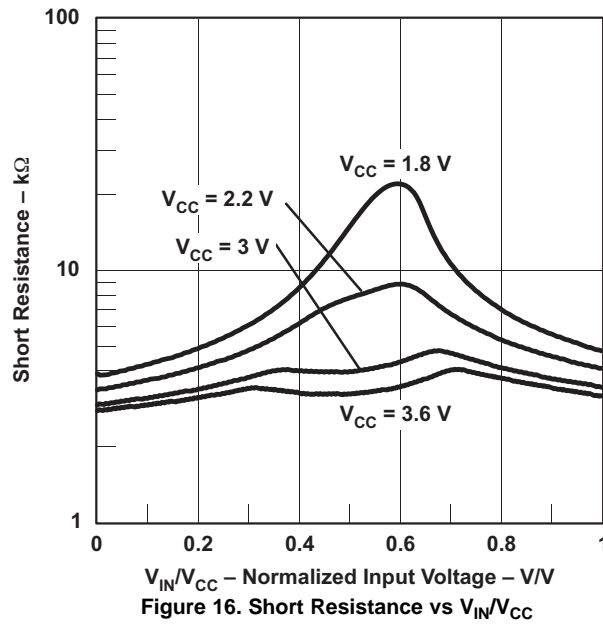


Figure 16. Short Resistance vs  $V_{IN}/V_{CC}$

## Flash Memory

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                  |  | TEST CONDITIONS       | V <sub>CC</sub> | MIN             | TYP             | MAX | UNIT             |
|----------------------------|--|-----------------------|-----------------|-----------------|-----------------|-----|------------------|
| V <sub>CC(PGM/ERASE)</sub> | Program and erase supply voltage                                   |                       |                 | 2.2             |                 | 3.6 | V                |
| f <sub>FTG</sub>           | Flash timing generator frequency                                   |                       |                 | 257             |                 | 476 | kHz              |
| I <sub>PGM</sub>           | Supply current from V <sub>CC</sub> during program                 |                       | 2.2 V, 3.6 V    |                 | 1               | 5   | mA               |
| I <sub>ERASE</sub>         | Supply current from V <sub>CC</sub> during erase                   |                       | 2.2 V, 3.6 V    |                 | 1               | 7   | mA               |
| t <sub>CPT</sub>           | Cumulative program time <sup>(1)</sup>                             |                       | 2.2 V, 3.6 V    |                 |                 | 10  | ms               |
| t <sub>CMErase</sub>       | Cumulative mass erase time   |                       | 2.2 V, 3.6 V    | 20              |                 |     | ms               |
|                            | Program and erase endurance  |                       |                 | 10 <sup>4</sup> | 10 <sup>5</sup> |     | cycles           |
| t <sub>Retention</sub>     | Data retention duration  | T <sub>J</sub> = 25°C |                 | 100             |                 |     | years            |
| t <sub>Word</sub>          | Word or byte program time <sup>(2)</sup>                           |                       |                 |                 | 30              |     | t <sub>FTG</sub> |
| t <sub>Block, 0</sub>      | Block program time for first byte or word <sup>(2)</sup>           |                       |                 |                 | 25              |     | t <sub>FTG</sub> |
| t <sub>Block, 1-63</sub>   | Block program time for each additional byte or word <sup>(2)</sup> |                       |                 |                 | 18              |     | t <sub>FTG</sub> |
| t <sub>Block, End</sub>    | Block program end-sequence wait time <sup>(2)</sup>                |                       |                 |                 | 6               |     | t <sub>FTG</sub> |
| t <sub>Mass Erase</sub>    | Mass erase time <sup>(2)</sup>                                     |                       |                 |                 | 10593           |     | t <sub>FTG</sub> |
| t <sub>Seg Erase</sub>     | Segment erase time <sup>(2)</sup>                                  |                       |                 |                 | 4819            |     | t <sub>FTG</sub> |

(1) The cumulative program time must not be exceeded when writing to a 64-byte flash block. This parameter applies to all programming methods: individual word write, byte write, and block write modes.

(2) These values are hardwired into the flash controller's state machine (t<sub>FTG</sub> = 1/f<sub>FTG</sub>).

## RAM

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER           |   | TEST CONDITIONS | MIN | MAX | UNIT |
|---------------------|---|-----------------|-----|-----|------|
| V <sub>(RAMh)</sub> | RAM retention supply voltage <sup>(1)</sup> | CPU halted      | 1.6 |     | V    |

(1) This parameter defines the minimum supply voltage V<sub>CC</sub> when the data in RAM remains unchanged. No program execution should happen during this supply voltage condition.

## JTAG and Spy-Bi-Wire Interface

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER             |  | V <sub>CC</sub> | MIN   | TYP | MAX | UNIT |
|-----------------------|--|-----------------|-------|-----|-----|------|
| f <sub>SBW</sub>      | Spy-Bi-Wire input frequency  | 2.2 V, 3 V      | 0     |     | 20  | MHz  |
| t <sub>SBW,Low</sub>  | Spy-Bi-Wire low clock pulse duration   | 2.2 V, 3 V      | 0.025 |     | 15  | μs   |
| t <sub>SBW,En</sub>   | Spy-Bi-Wire enable time<br>(TEST high to acceptance of first clock edge <sup>(1)</sup> ) | 2.2 V, 3 V      |       |     | 1   | μs   |
| t <sub>SBW,Ret</sub>  | Spy-Bi-Wire return to normal operation time  | 2.2 V, 3 V      | 15    |     | 100 | μs   |
| f <sub>TCK</sub>      | TCK input frequency <sup>(2)</sup>   | 2.2 V           | 0     |     | 5   | MHz  |
|                       |  | 3 V             | 0     |     | 10  | MHz  |
| R <sub>Internal</sub> | Internal pulldown resistance on TEST   | 2.2 V, 3 V      | 25    | 60  | 90  | kΩ   |

- (1) Tools accessing the Spy-Bi-Wire interface need to wait for the maximum t<sub>SBW,En</sub> time after pulling the TEST/SBWTCK pin high before applying the first SBWTCK clock edge.  
 (2) f<sub>TCK</sub> may be restricted to meet the timing requirements of the module selected.

## JTAG Fuse<sup>(1)</sup>

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER           |   | TEST CONDITIONS       | MIN | MAX | UNIT |
|---------------------|---|-----------------------|-----|-----|------|
| V <sub>CC(FB)</sub> | Supply voltage during fuse-blow condition | T <sub>A</sub> = 25°C | 2.5 |     | V    |
| V <sub>FB</sub>     | Voltage level on TEST for fuse blow       |                       | 6   | 7   | V    |
| I <sub>FB</sub>     | Supply current into TEST during fuse blow |                       |     | 100 | mA   |
| t <sub>FB</sub>     | Time to blow fuse                         |                       |     | 1   | ms   |

- (1) After the fuse is blown, no further access to the JTAG/Test, Spy-Bi-Wire, or emulation feature is possible, and JTAG is switched to bypass mode.

APPLICATION INFORMATION

Port P1 Pin Schematic: P1.0 to P1.3, Input/Output With Schmitt Trigger - MSP430G2x01

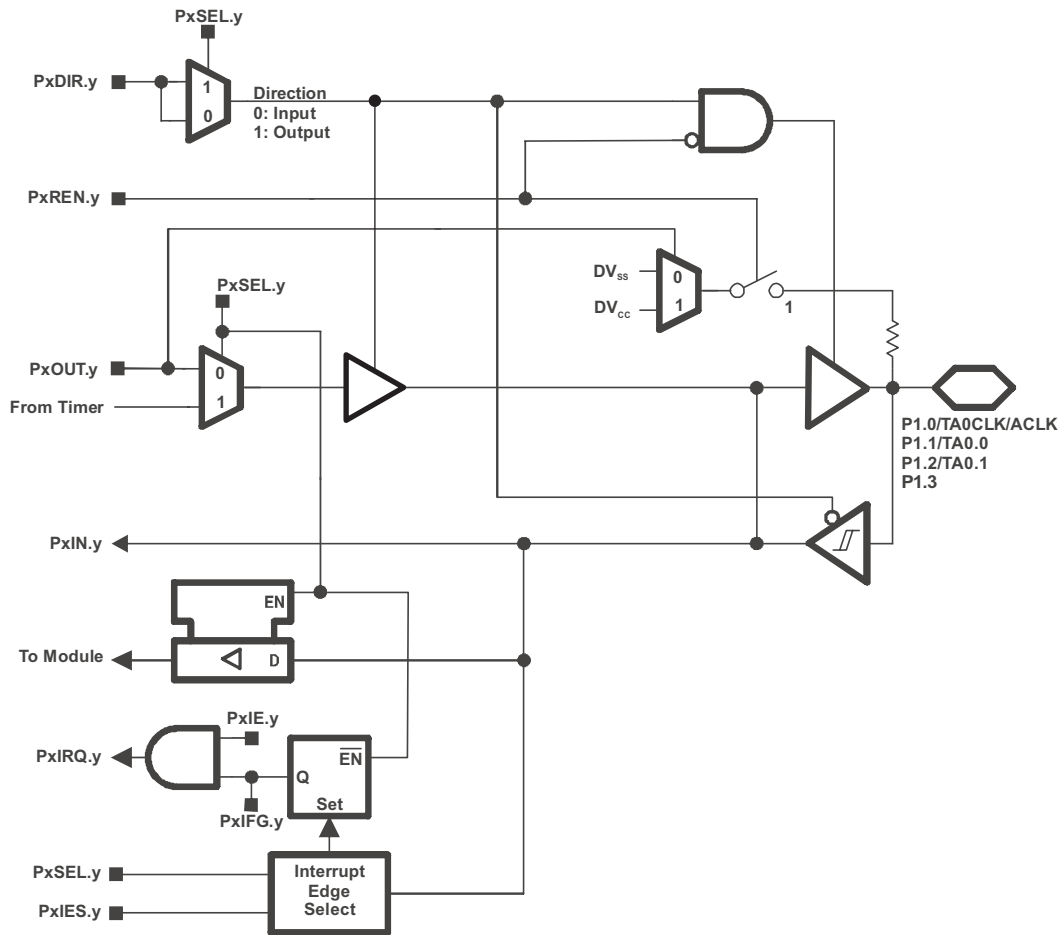


Table 14. Port P1 (P1.0 to P1.3) Pin Functions - MSP430G2x01

| PIN NAME (P1.x)          | x | FUNCTION   | CONTROL BITS/SIGNALS |         |
|--------------------------|---|------------|----------------------|---------|
|                          |   |            | P1DIR.x              | P1SEL.x |
| P1.0/<br>TA0CLK/<br>ACLK | 0 | P1.x (I/O) | I: 0; O: 1           | 0       |
|                          |   | TA0CLK     | 0                    | 1       |
|                          |   | ACLK       | 1                    | 1       |
| P1.1/<br>TA0.0           | 1 | P1.x (I/O) | I: 0; O: 1           | 0       |
|                          |   | TA0.CCI0A  | 0                    | 1       |
|                          |   | TA0.0      | 1                    | 1       |
| P1.2/<br>TA0.1           | 2 | P1.x (I/O) | I: 0; O: 1           | 0       |
|                          |   | TA0.CCI1A  | 0                    | 1       |
|                          |   | TA0.1      | 1                    | 1       |
| P1.3                     | 3 | P1.x (I/O) | I: 0; O: 1           | 0       |

Port P1 Pin Schematic: P1.4 to P1.7, Input/Output With Schmitt Trigger - MSP430G2x01

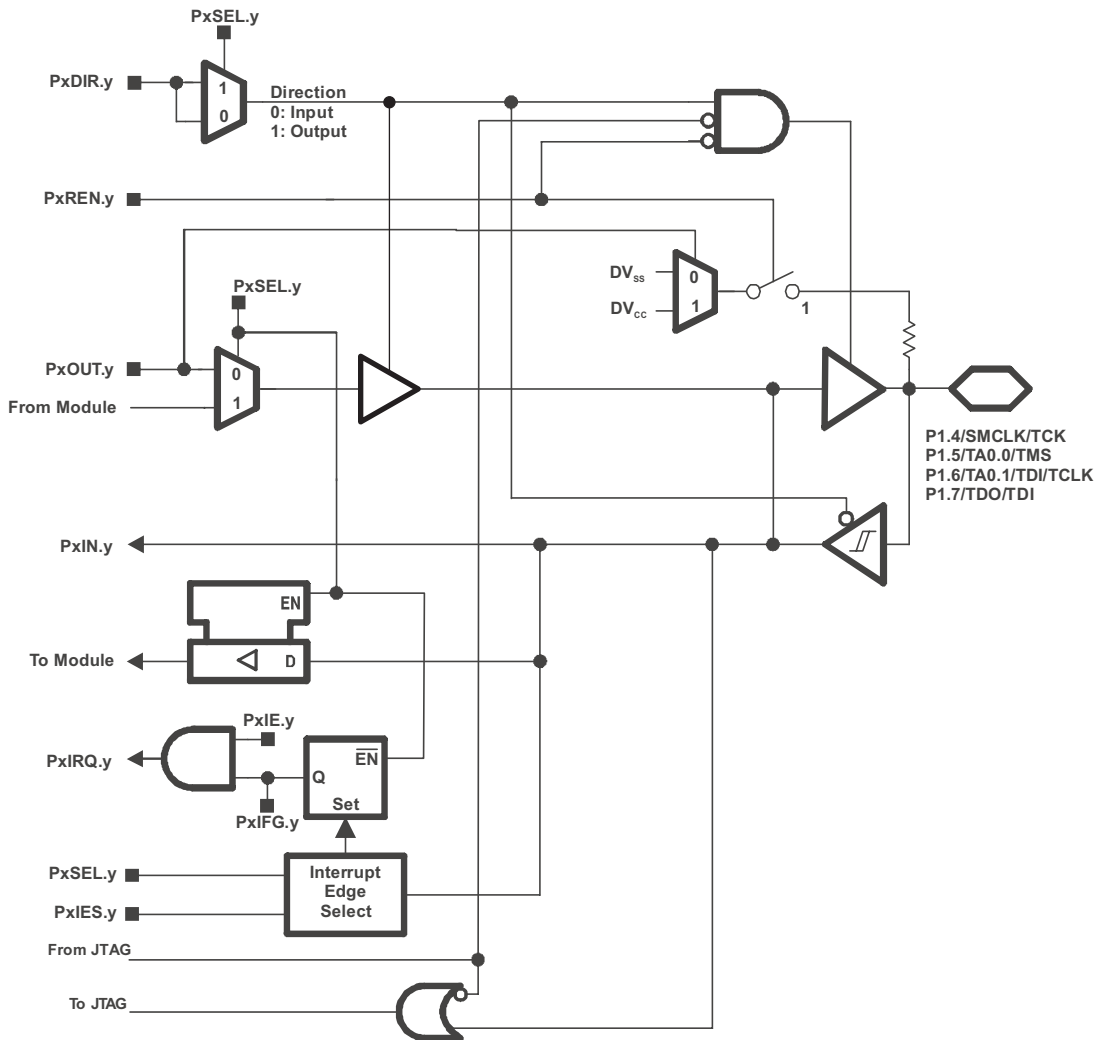
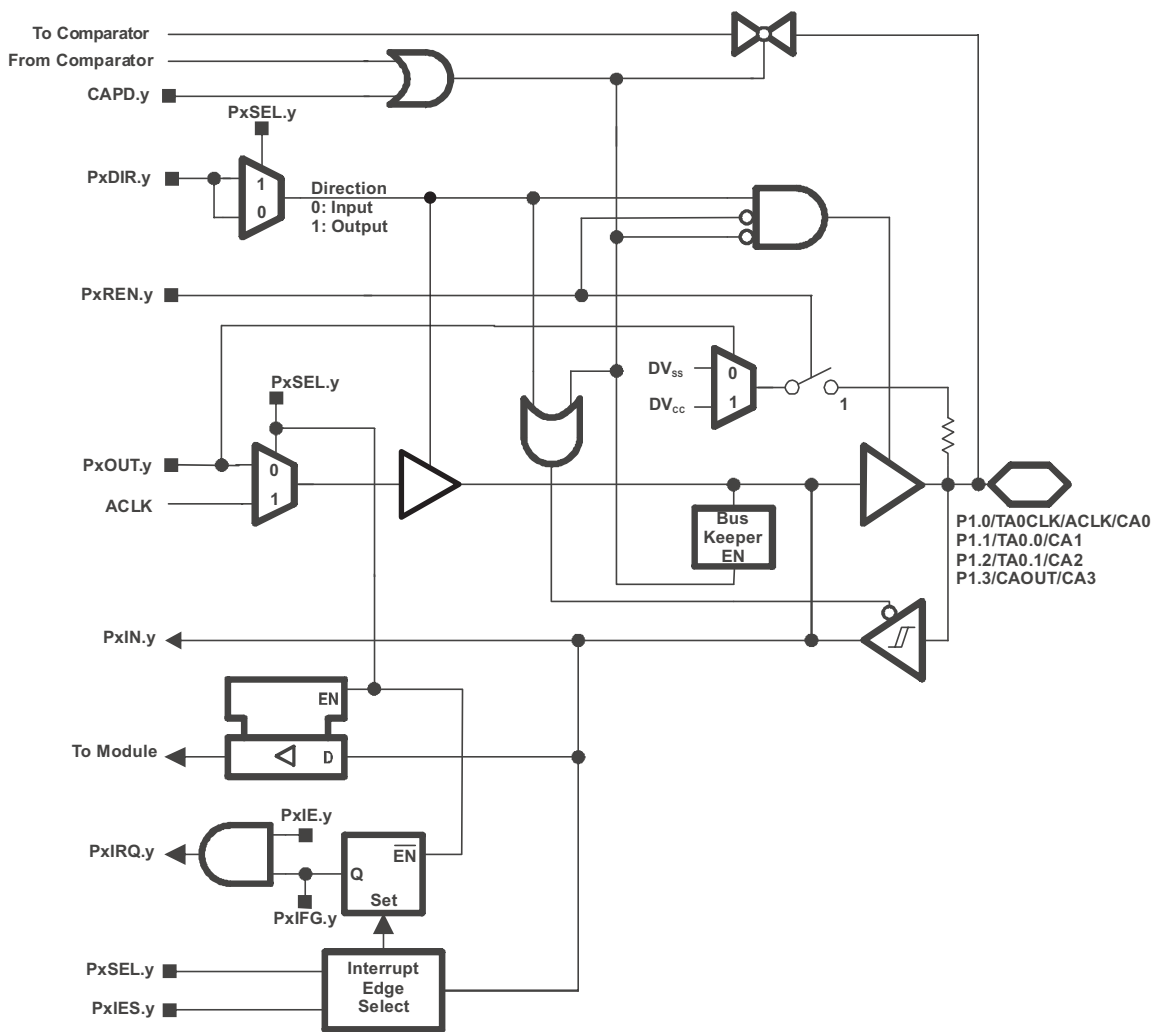


Table 15. Port P1 (P1.4 to P1.7) Pin Functions - MSP430G2x01

| PIN NAME (P1.x)             | x | FUNCTION   | CONTROL BITS / SIGNALS <sup>(1)</sup> |         |           |
|-----------------------------|---|------------|---------------------------------------|---------|-----------|
|                             |   |            | P1DIR.x                               | P1SEL.x | JTAG Mode |
| P1.4/<br>SMCLK/<br>TCK      | 4 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                             |   | SMCLK      | 1                                     | 1       | 0         |
|                             |   | TCK        | X                                     | X       | 1         |
| P1.5/<br>TA0.0/<br>TMS      | 5 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                             |   | TA0.0      | 1                                     | 1       | 0         |
|                             |   | TMS        | X                                     | X       | 1         |
| P1.6/<br>TA0.1/<br>TDI/TCLK | 6 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                             |   | TA0.1      | 1                                     | 1       | 0         |
|                             |   | TDI/TCLK   | X                                     | X       | 1         |
| P1.7/<br>TDO/TDI            | 7 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                             |   | TDO/TDI    | X                                     | X       | 1         |

(1) X = Don't care

Port P1 Pin Schematic: P1.0 to P1.3, Input/Output With Schmitt Trigger - MSP430G2x11

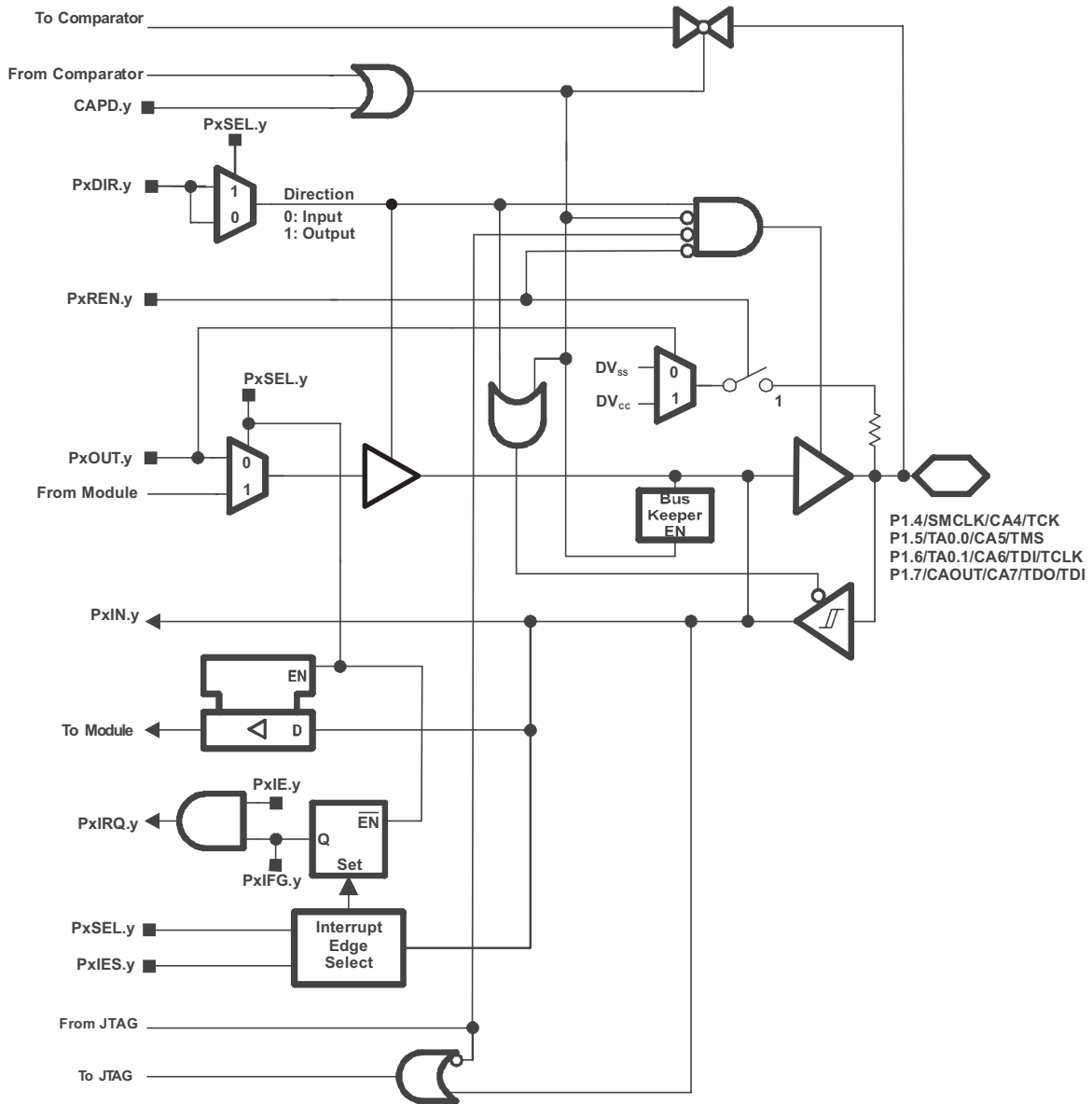


**Table 16. Port P1 (P1.0 to P1.3) Pin Functions - MSP430G2x11**

| PIN NAME (P1.x)                  | x | FUNCTION   | CONTROL BITS / SIGNALS <sup>(1)</sup> |         |           |
|----------------------------------|---|------------|---------------------------------------|---------|-----------|
|                                  |   |            | P1DIR.x                               | P1SEL.x | CAPD.y    |
| P1.0/<br>TA0CLK/<br>ACLK/<br>CA0 | 0 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                                  |   | TA0.TACLK  | 0                                     | 1       | 0         |
|                                  |   | ACLK       | 1                                     | 1       | 0         |
|                                  |   | CA0        | X                                     | X       | 1 (y = 0) |
| P1.1/<br>TA0.0/<br>CA1           | 1 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                                  |   | TA0.0      | 1                                     | 1       | 0         |
|                                  |   | TA0.CCI0A  | 0                                     | 1       | 0         |
|                                  |   | CA1        | X                                     | X       | 1 (y = 1) |
| P1.2/<br>TA0.1/<br>CA2           | 2 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                                  |   | TA0.1      | 1                                     | 1       | 0         |
|                                  |   | TA0.CCI1A  | 0                                     | 1       | 0         |
|                                  |   | CA2        | X                                     | X       | 1 (y = 2) |
| P1.3/<br>CAOUT/<br>CA3           | 3 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         |
|                                  |   | CAOUT      | 1                                     | 1       | 0         |
|                                  |   | CA3        | X                                     | X       | 1 (y = 3) |

(1) X = Don't care

Port P1 Pin Schematic: P1.4 to P1.7, Input/Output With Schmitt Trigger - MSP430G2x11



**Table 17. Port P1 (P1.4 to P1.7) Pin Functions - MSP430G2x11**

| PIN NAME (P1.x)                     | x | FUNCTION   | CONTROL BITS / SIGNALS <sup>(1)</sup> |         |           |           |
|-------------------------------------|---|------------|---------------------------------------|---------|-----------|-----------|
|                                     |   |            | P1DIR.x                               | P1SEL.x | JTAG Mode | CAPD.y    |
| P1.4/<br>SMCLK/<br>CA4/<br>TCK      | 4 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         | 0         |
|                                     |   | SMCLK      | 1                                     | 1       | 0         | 0         |
|                                     |   | CA4        | X                                     | X       | 0         | 1 (y = 4) |
|                                     |   | TCK        | X                                     | X       | 1         | 0         |
| P1.5/<br>TA0.0/<br>CA5/<br>TMS      | 5 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         | 0         |
|                                     |   | TA0.0      | 1                                     | 1       | 0         | 0         |
|                                     |   | CA5        | X                                     | X       | 0         | 1 (y = 5) |
|                                     |   | TMS        | X                                     | X       | 1         | 0         |
| P1.6/<br>TA0.1/<br>CA6/<br>TDI/TCLK | 6 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         | 0         |
|                                     |   | TA0.1      | 1                                     | 1       | 0         | 0         |
|                                     |   | CA6        | X                                     | X       | 0         | 1 (y = 6) |
|                                     |   | TDI/TCLK   | X                                     | X       | 1         | 0         |
| P1.7/<br>CAOUT/<br>CA7/<br>TDO/TDI  | 7 | P1.x (I/O) | I: 0; O: 1                            | 0       | 0         | 0         |
|                                     |   | CAOUT      | 1                                     | 1       | 0         | 0         |
|                                     |   | CA7        | X                                     | X       | 0         | 1 (y = 7) |
|                                     |   | TDO/TDI    | X                                     | X       | 1         | 0         |

(1) X = Don't care

Port P2 Pin Schematic: P2.6, Input/Output With Schmitt Trigger - MSP430G2x01 and MSP430G2x11

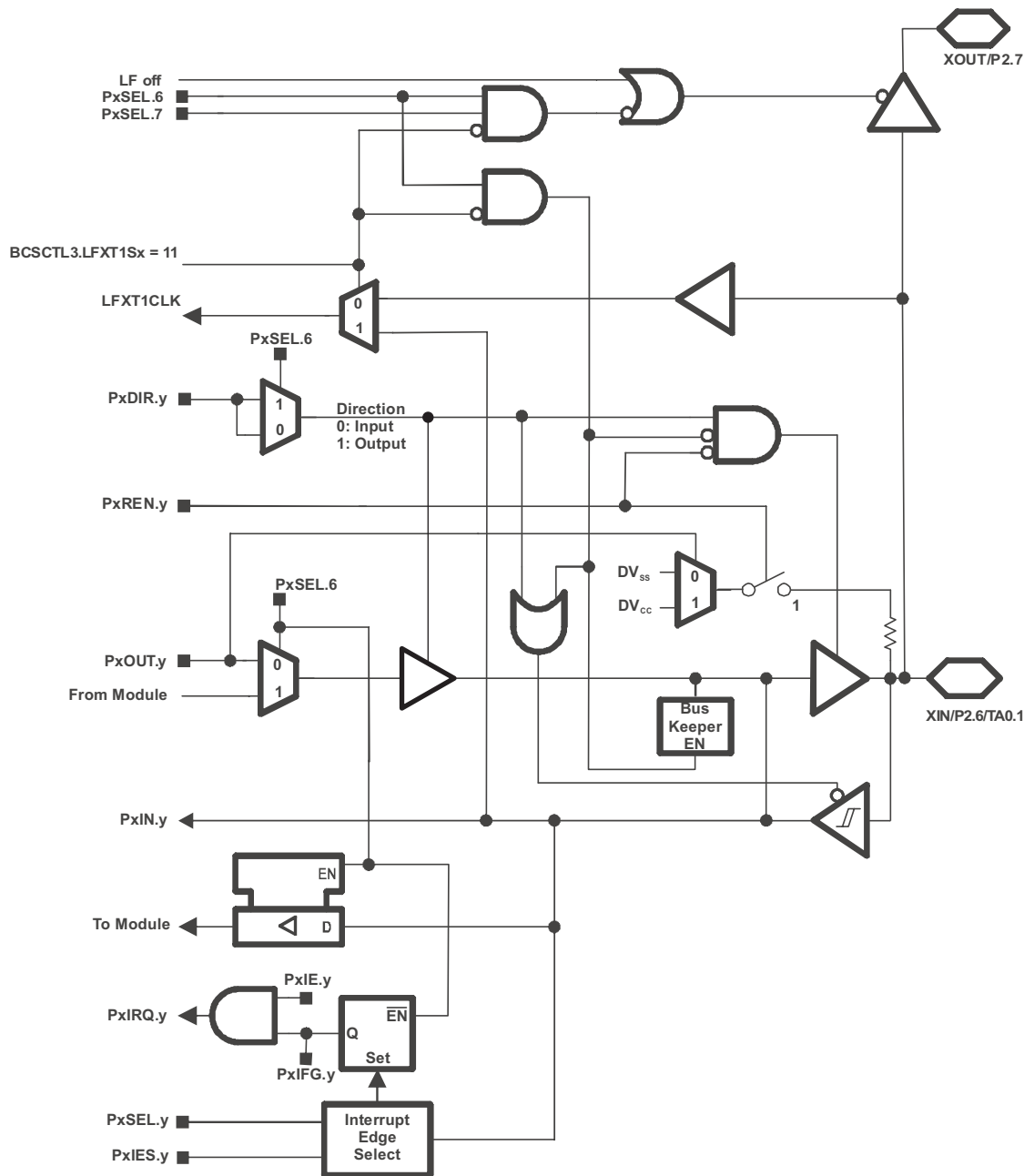


Table 18. Port P2 (P2.6) Pin Functions - MSP430G2x01 and MSP430G2x11

| PIN NAME (P2.x) | x | FUNCTION      | CONTROL BITS / SIGNALS <sup>(1)</sup> |         |         |
|-----------------|---|---------------|---------------------------------------|---------|---------|
|                 |   |               | P2DIR.x                               | P2SEL.6 | P2SEL.7 |
| XIN             | 6 | XIN           | 0                                     | 1       | 1       |
| P2.6            |   | P2.x (I/O)    | I: 0; O: 1                            | 0       | X       |
| TA0.1           |   | Timer0_A2.TA1 | 1                                     | 1       | X       |

(1) X = Don't care

Port P2 Pin Schematic: P2.7, Input/Output With Schmitt Trigger - MSP430G2x01 and MSP430G2x11

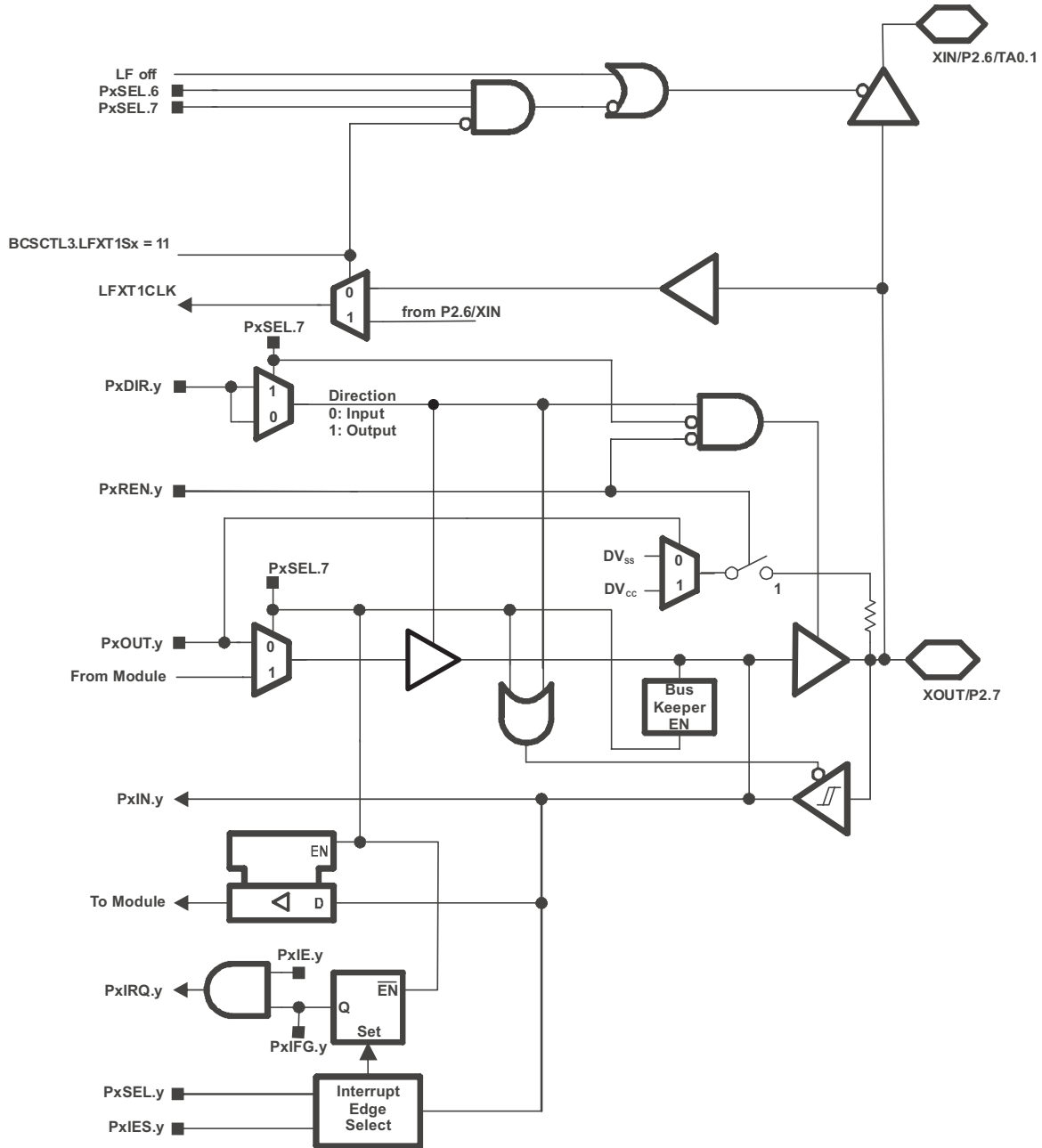


Table 19. Port P2 (P2.7) Pin Functions - MSP430G2x01 and MSP430G2x11

| PIN NAME (P2.x) | x | FUNCTION   | CONTROL BITS / SIGNALS |         |         |
|-----------------|---|------------|------------------------|---------|---------|
|                 |   |            | P2DIR.x                | P2SEL.6 | P2SEL.7 |
| XOUT            | 7 | XOUT       | 1                      | 1       | 1       |
| P2.7            |   | P2.x (I/O) | I: 0; O: 1             | 0       | 0       |

## REVISION HISTORY

| REVISION | DESCRIPTION  |
|----------|--|
| SLAS695  | Limited Product Preview release  |
| SLAS695A | Updated Product Preview<br>Changes throughout for sampling   |
| SLAS695B | Updated Product Preview  |
| SLAS695C | Production Data release  |
| SLAS695D | <a href="#">Table 14</a> , Corrected P1DIR.x column for TA0.0 and TA0.1.<br><a href="#">Table 18</a> , Corrected FUNCTION column for TA0.1.<br><a href="#">Port P1 Pin Schematic: P1.0 to P1.3, Input/Output With Schmitt Trigger – MSP430G2x11</a> , Corrected schematic. |
| SLAS695E | Changed Storage temperature range limits in <a href="#">Absolute Maximum Ratings</a> .<br><a href="#">Table 15</a> , Removed CAPD.y column.<br><a href="#">Table 19</a> , Corrected Control Bits/Signals.  |
| SLAS695F | Changed $T_{stg}$ , Programmed device, to -55°C to 150°C in <a href="#">Absolute Maximum Ratings</a> .<br>Changed $f_{SYSTEM\ MAX}$ at $V_{CC} = 1.8\ V$ from 4.15 to 6 MHz in <a href="#">Recommended Operating Conditions</a> .  |
| SLAS695G | Changed port schematics (added buffer after PxOUT.y mux) in <a href="#">APPLICATION INFORMATION</a>  |
| SLAS695H | <a href="#">Table 2</a> , Added pin 13 to NC list for RSA-16 package<br><a href="#">Recommended Operating Conditions</a> , Added test conditions for typical values.<br><a href="#">POR, BOR</a> , Added note (2).   |
| SLAS695I | Removed all information related to operation at T temperature (-40°C to 105°C).  |

**PACKAGING INFORMATION**

| Orderable Device   | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|--------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MSP430G2001IN14    | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MSP430G2001             | <a href="#">Samples</a> |
| MSP430G2001IPW14   | ACTIVE        | TSSOP        | PW                 | 14   | 90             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2001                   | <a href="#">Samples</a> |
| MSP430G2001IPW14R  | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2001                   | <a href="#">Samples</a> |
| MSP430G2001IRSA16R | ACTIVE        | QFN          | RSA                | 16   | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2001           | <a href="#">Samples</a> |
| MSP430G2001IRSA16T | ACTIVE        | QFN          | RSA                | 16   | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2001           | <a href="#">Samples</a> |
| MSP430G2101IN14    | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MSP430G2101             | <a href="#">Samples</a> |
| MSP430G2101IPW14   | ACTIVE        | TSSOP        | PW                 | 14   | 90             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2101                   | <a href="#">Samples</a> |
| MSP430G2101IPW14R  | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2101                   | <a href="#">Samples</a> |
| MSP430G2101IRSA16R | ACTIVE        | QFN          | RSA                | 16   | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2101           | <a href="#">Samples</a> |
| MSP430G2101IRSA16T | ACTIVE        | QFN          | RSA                | 16   | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2101           | <a href="#">Samples</a> |
| MSP430G2111IN14    | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MSP430G2111             | <a href="#">Samples</a> |
| MSP430G2111IPW14   | ACTIVE        | TSSOP        | PW                 | 14   | 90             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2111                   | <a href="#">Samples</a> |
| MSP430G2111IPW14R  | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2111                   | <a href="#">Samples</a> |
| MSP430G2111IRSA16R | ACTIVE        | QFN          | RSA                | 16   | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2111           | <a href="#">Samples</a> |
| MSP430G2111IRSA16T | ACTIVE        | QFN          | RSA                | 16   | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2111           | <a href="#">Samples</a> |
| MSP430G2201IN14    | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MSP430G2201             | <a href="#">Samples</a> |
| MSP430G2201IPW14   | ACTIVE        | TSSOP        | PW                 | 14   | 90             | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2201                   | <a href="#">Samples</a> |
| MSP430G2201IPW14R  | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2201                   | <a href="#">Samples</a> |
| MSP430G2201IRSA16R | ACTIVE        | QFN          | RSA                | 16   | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G                   | <a href="#">Samples</a> |

| Orderable Device  | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|-------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
|                   |               |              |                 |      |             |                 |                                      |                      |              | 2201                    |                         |
| MSP430G2201RSA16T | ACTIVE        | QFN          | RSA             | 16   | 250         | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2201           | <a href="#">Samples</a> |
| MSP430G2211IN14   | ACTIVE        | PDIP         | N               | 14   | 25          | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | MSP430G2211             | <a href="#">Samples</a> |
| MSP430G2211IPW14  | ACTIVE        | TSSOP        | PW              | 14   | 90          | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2211                   | <a href="#">Samples</a> |
| MSP430G2211IPW14R | ACTIVE        | TSSOP        | PW              | 14   | 2000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 85    | G2211                   | <a href="#">Samples</a> |
| MSP430G2211RSA16R | ACTIVE        | QFN          | RSA             | 16   | 3000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2211           | <a href="#">Samples</a> |
| MSP430G2211RSA16T | ACTIVE        | QFN          | RSA             | 16   | 250         | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 85    | M430G<br>2211           | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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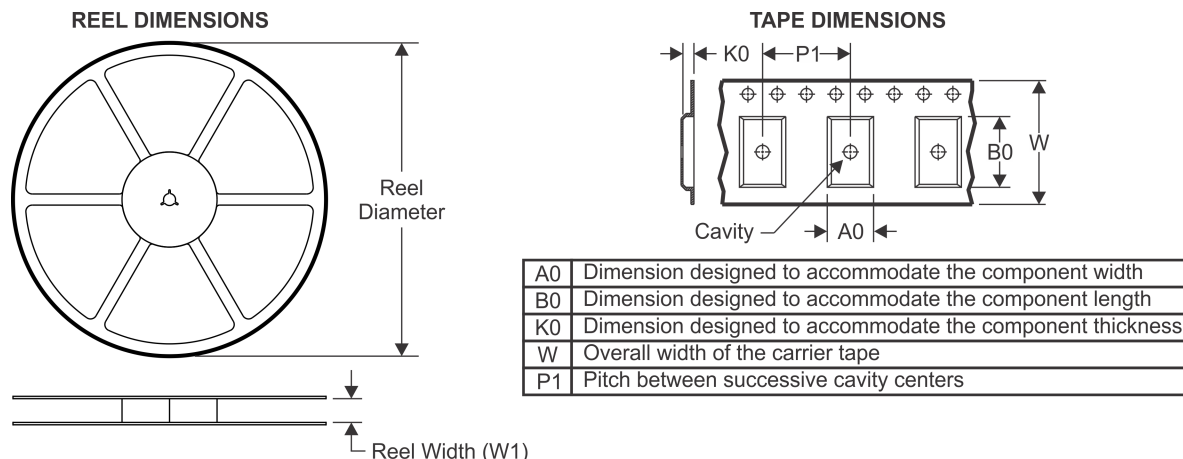
**OTHER QUALIFIED VERSIONS OF MSP430G2201 :**

- Automotive: [MSP430G2201-Q1](#)

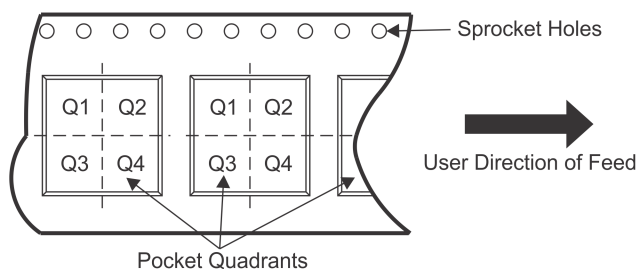
NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



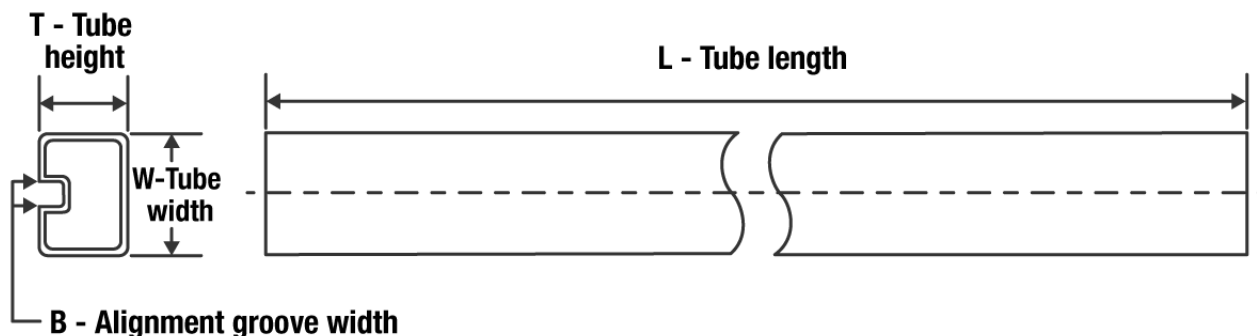
\*All dimensions are nominal

| Device             | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MSP430G2001IPW14R  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MSP430G2001IRSA16R | QFN          | RSA             | 16   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2001IRSA16T | QFN          | RSA             | 16   | 250  | 180.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2101IPW14R  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MSP430G2101IRSA16R | QFN          | RSA             | 16   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2101IRSA16T | QFN          | RSA             | 16   | 250  | 180.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2111IPW14R  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MSP430G2111IRSA16R | QFN          | RSA             | 16   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2111IRSA16T | QFN          | RSA             | 16   | 250  | 180.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2201IPW14R  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MSP430G2201IRSA16R | QFN          | RSA             | 16   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2201IRSA16T | QFN          | RSA             | 16   | 250  | 180.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2211IPW14R  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| MSP430G2211IRSA16R | QFN          | RSA             | 16   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| MSP430G2211IRSA16T | QFN          | RSA             | 16   | 250  | 180.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device             | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MSP430G2001IPW14R  | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| MSP430G2001IRSA16R | QFN          | RSA             | 16   | 3000 | 367.0       | 367.0      | 35.0        |
| MSP430G2001IRSA16T | QFN          | RSA             | 16   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430G2101IPW14R  | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| MSP430G2101IRSA16R | QFN          | RSA             | 16   | 3000 | 367.0       | 367.0      | 35.0        |
| MSP430G2101IRSA16T | QFN          | RSA             | 16   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430G2111IPW14R  | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| MSP430G2111IRSA16R | QFN          | RSA             | 16   | 3000 | 367.0       | 367.0      | 35.0        |
| MSP430G2111IRSA16T | QFN          | RSA             | 16   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430G2201IPW14R  | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| MSP430G2201IRSA16R | QFN          | RSA             | 16   | 3000 | 367.0       | 367.0      | 35.0        |
| MSP430G2201IRSA16T | QFN          | RSA             | 16   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430G2211IPW14R  | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| MSP430G2211IRSA16R | QFN          | RSA             | 16   | 3000 | 367.0       | 367.0      | 35.0        |
| MSP430G2211IRSA16T | QFN          | RSA             | 16   | 250  | 210.0       | 185.0      | 35.0        |

**TUBE**


\*All dimensions are nominal

| Device           | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| MSP430G2001IN14  | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| MSP430G2001IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2001IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2101IN14  | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| MSP430G2101IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2101IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2111IN14  | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| MSP430G2111IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2111IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2201IN14  | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| MSP430G2201IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2201IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2211IN14  | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| MSP430G2211IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| MSP430G2211IPW14 | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |



PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4211284-2/G 08/15

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

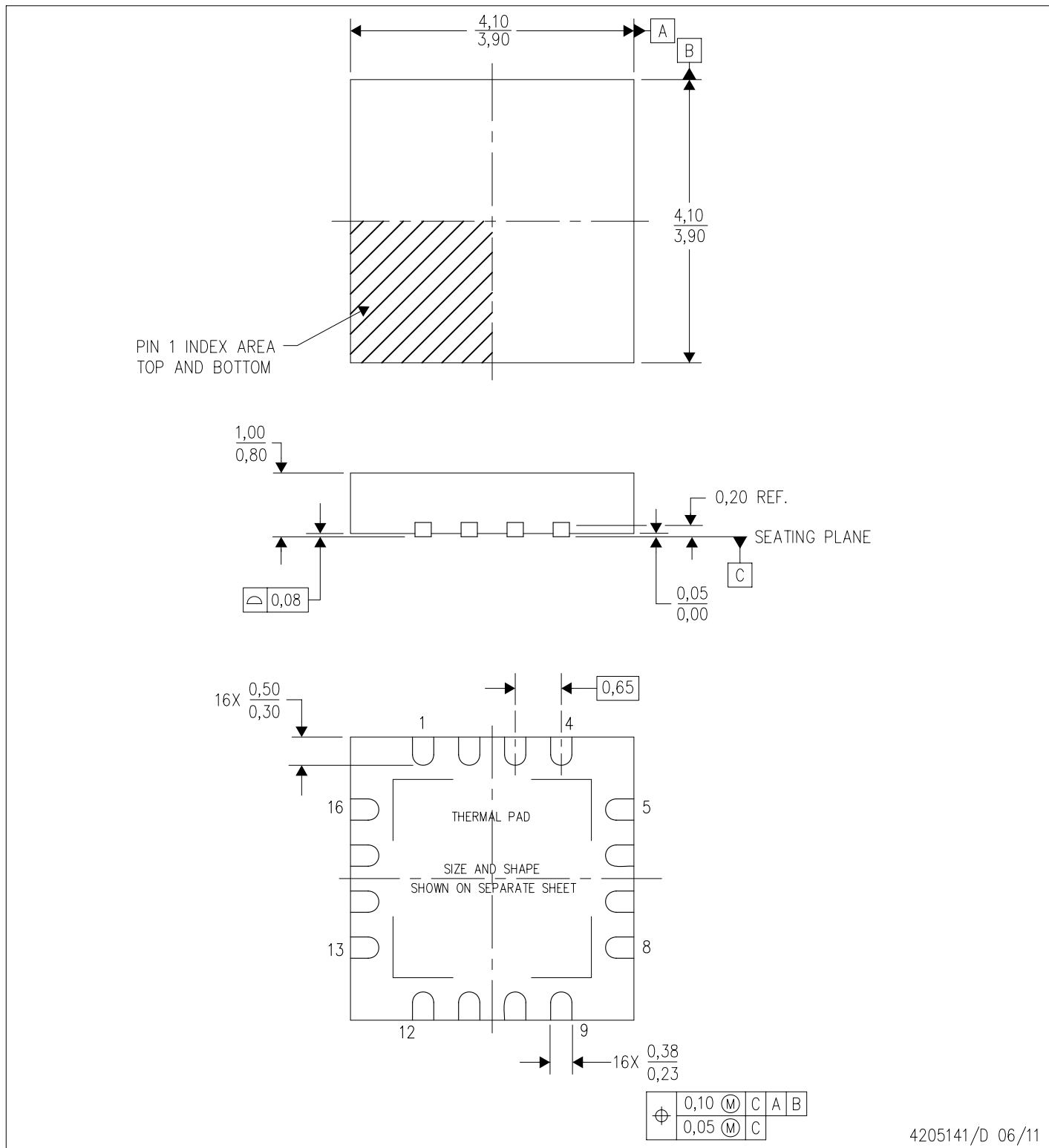


4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - $\triangle D$  The 20 pin end lead shoulder width is a vendor option, either half or full width.

RSA (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4205141/D 06/11

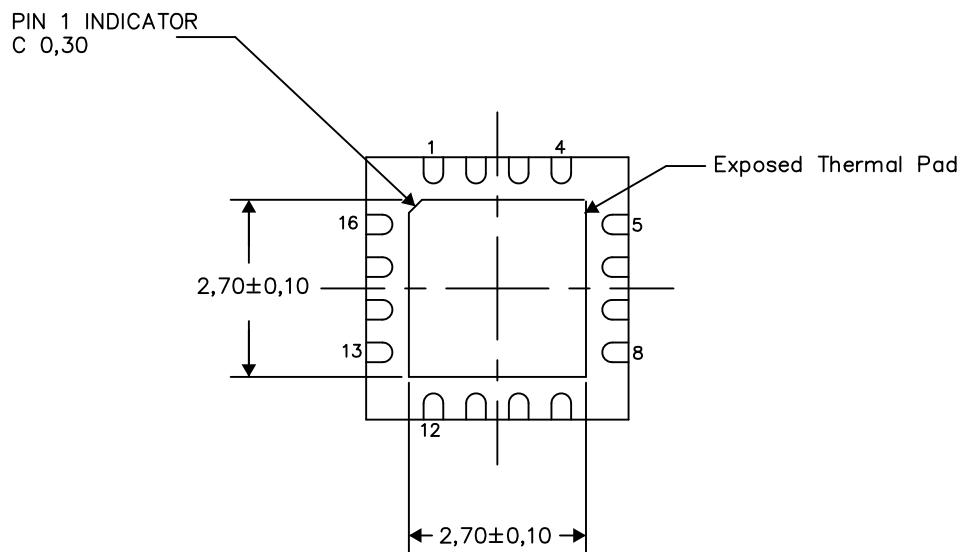
- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - Quad Flatpack, No-leads (QFN) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - Falls within JEDEC MO-220.

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

Exposed Thermal Pad Dimensions

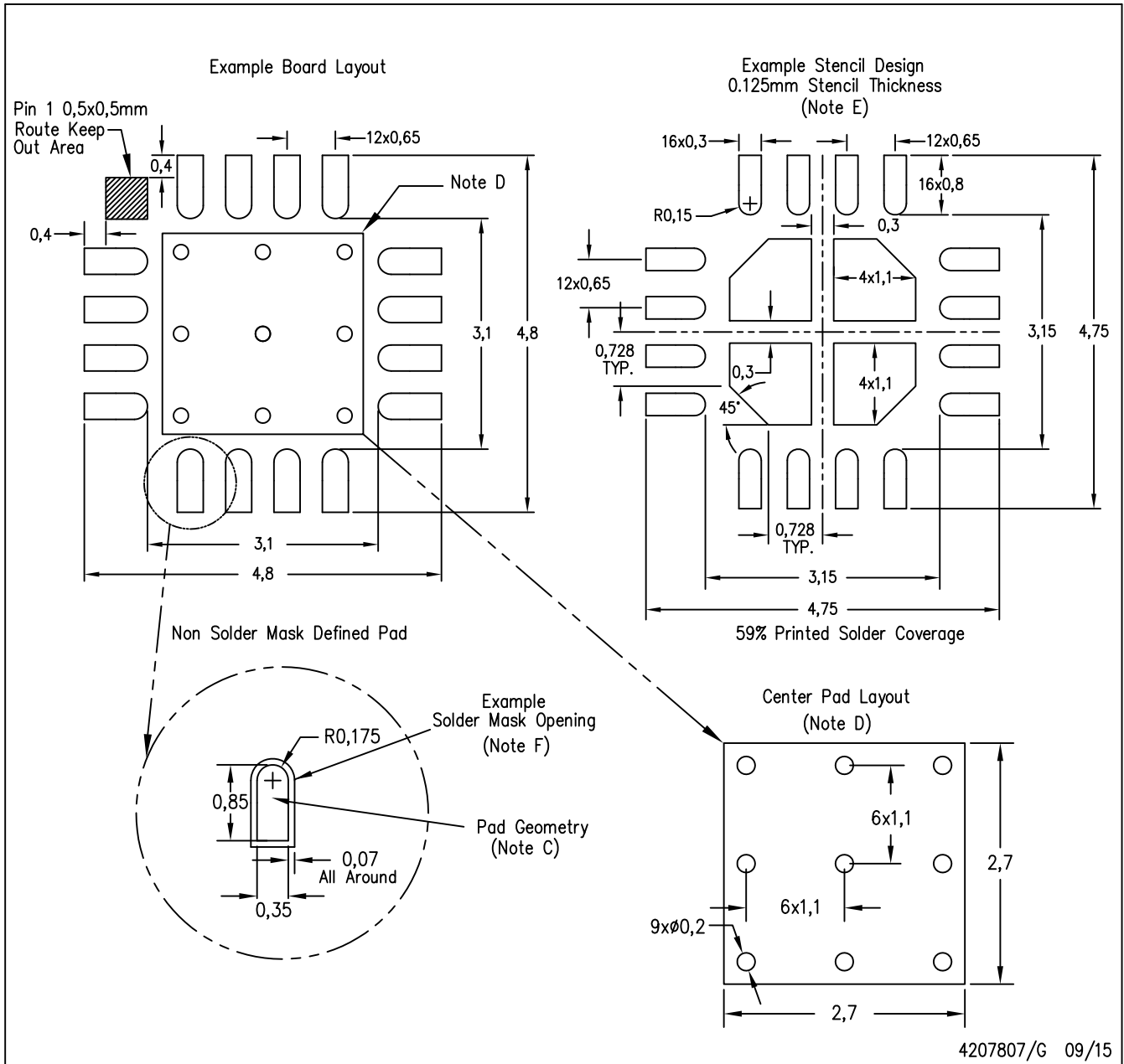
4206364-2/0 09/15

### NOTES:

- A. All linear dimensions are in millimeters

RSA (S-PVQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4207807/G 09/15

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, QFN Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - F. Customers should contact their board fabrication site for solder mask tolerances.

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