TMS320DM357 DMSoC Inter-Integrated Circuit (I2C) Peripheral

User's Guide

Literature Number: SPRUG27
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About This Manual

This document describes the inter-integrated circuit (I2C) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The I2C peripheral provides an interface between the DMSoC and other devices that are compliant with Philips Semiconductors Inter-IC bus (I2C-bus) specification version 2.1 and connected by way of an I2C-bus. The scope of this document assumes that you are familiar with the I2C-bus specification.

Notational Conventions

This document uses the following conventions.

- Hexadecimal numbers are shown with the suffix h. For example, the following number is 40 hexadecimal (decimal 64): 40h.
- Registers in this document are shown in figures and described in tables.
  - Each register figure shows a rectangle divided into fields that represent the fields of the register. Each field is labeled with its bit name, its beginning and ending bit numbers above, and its read/write properties below. A legend explains the notation used for the properties.
  - Reserved bits in a register figure designate a bit that is used for future device expansion.

Related Documentation From Texas Instruments

The following documents describe the TMS320DM357 Digital Media System-on-Chip (DMSoC). Copies of these documents are available on the Internet at www.ti.com. *Tip:* Enter the literature number in the search box provided at www.ti.com.

SPRUG06 — ***TMS320DM357 DMSoC Video Processing Back End (VPBE) User's Guide.*** Describes the video processing back end (VPBE) in the TMS320DM357 Digital Media System-on-Chip (DMSoC) video processing subsystem. Included in the VPBE is the video encoder, on-screen display, and digital LCD controller.

SPRUG25 — ***TMS320DM357 DMSoC ARM Subsystem Reference Guide.*** Describes the ARM subsystem in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The ARM subsystem is designed to give the ARM926EJ-S (ARM9) master control of the device. In general, the ARM is responsible for configuration and control of the device; including the video processing subsystem, and a majority of the peripherals and external memories.

SPRUG26 — ***TMS320DM357 DMSoC Universal Asynchronous Receiver/Transmitter (UART) User's Guide.*** This document describes the universal asynchronous receiver/transmitter (UART) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The UART peripheral performs serial-to-parallel conversion on data received from a peripheral device, and parallel-to-serial conversion on data received from the CPU.

SPRUG27 — ***TMS320DM357 DMSoC Inter-Integrated Circuit (I2C) Peripheral User's Guide.*** Describes the inter-integrated circuit (I2C) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The I2C peripheral provides an interface between the DMSoC and other devices compliant with the I2C-bus specification and connected by way of an I2C-bus. External components attached to this 2-wire serial bus can transmit and receive up to 8-bit wide data to and from the DMSoC through the I2C peripheral. This document assumes the reader is familiar with the I2C-bus specification.

SPRUG28 — ***TMS320DM357 DMSoC 64-Bit Timer User's Guide.*** Describes the operation of the software-programmable 64-bit timer in the TMS320DM357 Digital Media System-on-Chip (DMSoC). Timer 0 and Timer 1 are used as general-purpose (GP) timers and can be programmed in 64-bit mode, dual 32-bit unchained mode, or dual 32-bit chained mode; Timer 2 is used only as a watchdog timer. The GP timer modes can be used to generate periodic interrupts or enhanced direct memory access (EDMA) synchronization events. The watchdog timer mode is used to provide a recovery mechanism for the device in the event of a fault condition, such as a non-exiting code loop.

SPRUG29 — ***TMS320DM357 DMSoC Serial Peripheral Interface (SPI) User's Guide.*** Describes the serial peripheral interface (SPI) in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The SPI is a high-speed synchronous serial input/output port that allows a serial bit stream of programmed length (1 to 16 bits) to be shifted into and out of the device at a programmed bit-transfer rate. The SPI is normally used for communication between the DMSoC and external peripherals. Typical applications include an interface to external I/O or peripheral expansion via devices such as shift registers, display drivers, SPI EPROMs and analog-to-digital converters.

SPRUG30 — ***TMS320DM357 DMSoC Host Port Interface (HPI) Reference Guide.*** This document describes the host port interface in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The HPI provides a parallel port interface through which an external host processor can directly access the TMS320DM357 DMSoC processor's resources (configuration and program/data memories).

SPRUG31 — ***TMS320DM357 DMSoC General-Purpose Input/Output (GPIO) User's Guide.*** Describes the general-purpose input/output (GPIO) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The GPIO peripheral provides dedicated general-purpose pins that can be configured as either inputs or outputs. When configured as an input, you can detect the state of the input by reading the state of an internal register. When configured as an output, you can write to an internal register to control the state driven on the output pin.

SPRUG32 — ***TMS320DM357 DMSoC Multimedia Card (MMC)/Secure Digital (SD) Card Controller User's Guide.*** Describes the multimedia card (MMC)/secure digital (SD) card controller in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The MMC/SD card is used in a number of applications to provide removable data storage. The MMC/SD controller provides an interface to external MMC and SD cards. The communication between the MMC/SD controller and MMC/SD card(s) is performed by the MMC/SD protocol.

SPRUG33 — ***TMS320DM357 DMSoC Asynchronous External Memory Interface (EMIF) User's Guide.*** Describes the asynchronous external memory interface (EMIF) in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The EMIF supports a glueless interface to a variety of external devices.

SPRUG34 — ***TMS320DM357 DMSoC Enhanced Direct Memory Access (EDMA) Controller User's Guide.*** Describes the operation of the enhanced direct memory access (EDMA3) controller in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The EDMA3 controller's primary purpose is to service user-programmed data transfers between two memory-mapped slave endpoints on the DMSoC.

SPRUG35 — ***TMS320DM357 DMSoC Audio Serial Port (ASP) User's Guide.*** Describes the operation of the audio serial port (ASP) audio interface in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The primary audio modes that are supported by the ASP are the AC97 and IIS modes. In addition to the primary audio modes, the ASP supports general serial port receive and transmit operation, but is not intended to be used as a high-speed interface.

SPRUG36 — ***TMS320DM357 DMSoC Ethernet Media Access Controller (EMAC)/Management Data Input/Output (MDIO) Module User's Guide.*** Discusses the ethernet media access controller (EMAC) and physical layer (PHY) device management data input/output (MDIO) module in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The EMAC controls the flow of packet data from the DMSoC to the PHY. The MDIO module controls PHY configuration and status monitoring.

SPRUG37 — ***TMS320DM357 DMSoC Pulse-Width Modulator (PWM) Peripheral User's Guide.*** Describes the pulse-width modulator (PWM) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC).

SPRUG38 — ***TMS320DM357 DMSoC DDR2 Memory Controller User's Guide.*** Describes the DDR2 memory controller in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The DDR2 memory controller is used to interface with JESD79D-2A standard compliant DDR2 SDRAM devices.

SPRUG39 — ***TMS320DM357 DMSoC Video Processing Front End (VPFE) User's Guide.*** Describes the video processing front end (VPFE) in the TMS320DM357 Digital Media System-on-Chip (DMSoC) video processing subsystem. Included in the VPFE is the preview engine, CCD controller, resizer, histogram, and hardware 3A (H3A) statistic generator.

SPRUGH2 — ***TMS320DM357 DMSoC Peripherals Overview Reference Guide.*** This document provides an overview of the peripherals in the TMS320DM357 Digital Media System-on-Chip (DMSoC).

SPRUGH3 — ***TMS320DM357 DMSoC Universal Serial Bus Controller User's Guide.*** This document describes the universal serial bus (USB) controller in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The USB controller supports data throughput rates up to 480 Mbps. It provides a mechanism for data transfer between USB devices and also supports host negotiation.

Trademarks

Inter-Integrated Circuit (I2C) Peripheral

1 Introduction

This document describes the operation of the inter-integrated circuit (I2C) peripheral in the TMS320DM357 Digital Media System-on-Chip (DMSoC). The scope of this document assumes that you are familiar with the Philips Semiconductors Inter-IC bus (I2C-bus) specification version 2.1.

1.1 Purpose of the Peripheral

The I2C peripheral provides an interface between the DMSoC and other devices that are compliant with the I2C-bus specification and connected by way of an I2C-bus. External components that are attached to this two-wire serial bus can transmit and receive data that is up to eight bits wide both to and from the DMSoC through the I2C peripheral.

1.2 Features

The I2C peripheral has the following features:

- Compliance with the Philips Semiconductors I2C-bus specification (version 2.1):
  - Support for byte format transfer
  - 7-bit and 10-bit addressing modes
  - General call
  - START byte mode
  - Support for multiple master-transmitters and slave-receivers mode
  - Support for multiple slave-transmitters and master-receivers mode
  - Combined master transmit/receive and receive/transmit mode
  - I2C data transfer rate of from 10 kbps up to 400 kbps (Philips I2C rate)
- 2 to 7 bit format transfer
- Free data format mode
- One read DMA event and one write DMA event that the DMA can use
- Seven interrupts that the CPU can use
- Peripheral enable/disable capability

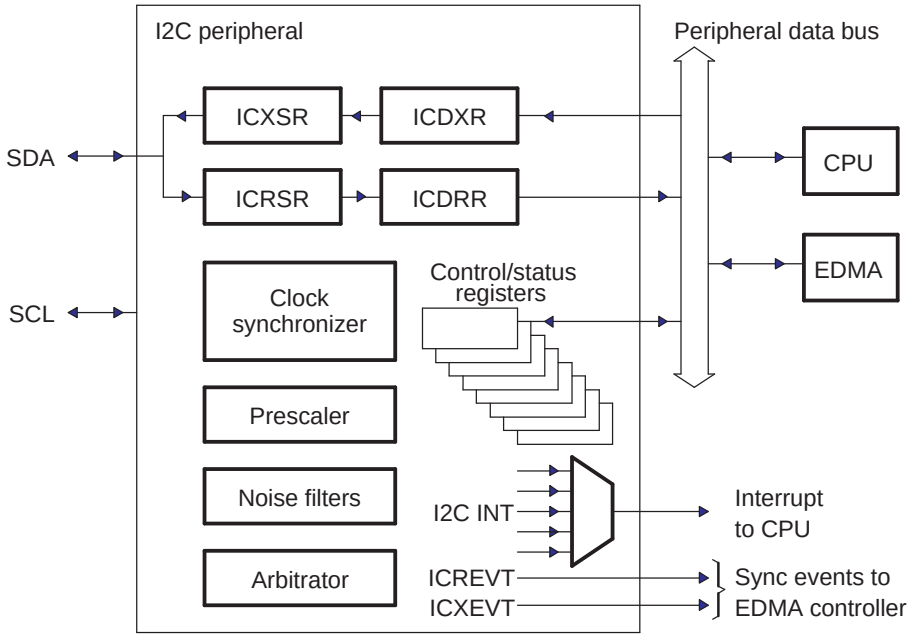
1.2.1 Features Not Supported

- High-speed mode
- CBUS-compatibility mode
- The combined format in 10-bit addressing mode (the I2C sends the slave address the second byte every time it sends the slave address the first byte).

1.3 Functional Block Diagram

A block diagram of the I2C peripheral is shown in Figure 1. Refer to Section 2 for detailed information about the architecture of the I2C peripheral.

Figure 1. I2C Peripheral Block Diagram



1.4 Industry Standard(s) Compliance Statement

The I2C peripheral is compliant with the Philips Semiconductors Inter-IC bus (I2C-bus) specification version 2.1.

2 Peripheral Architecture

The I2C peripheral consists of the following primary blocks:

- A serial interface: one data pin (SDA) and one clock pin (SCL)
- Data registers to temporarily hold receive data and transmit data traveling between the SDA pin and the CPU or the EDMA controller
- Control and status registers
- A peripheral data bus interface to enable the CPU and the EDMA controller to access the I2C peripheral registers
- A clock synchronizer to synchronize the I2C input clock (from the processor clock generator) and the clock on the SCL pin, and to synchronize data transfers with masters of different clock speeds
- A prescaler to divide down the input clock that is driven to the I2C peripheral
- A noise filter on each of the two pins, SDA and SCL
- An arbitrator to handle arbitration between the I2C peripheral (when it is a master) and another master
- Interrupt generation logic, so that an interrupt can be sent to the CPU
- EDMA event generation logic, so that activity in the EDMA controller can be synchronized to data reception and data transmission in the I2C peripheral

Figure 1 shows the four registers used for transmission and reception. The CPU or the EDMA controller writes data for transmission to ICDXR and reads received data from ICDRR. When the I2C peripheral is configured as a transmitter, data written to ICDXR is copied to ICXSR and shifted out on the SDA pin one bit a time. When the I2C peripheral is configured as a receiver, received data is shifted into ICRSR and then copied to ICDRR.

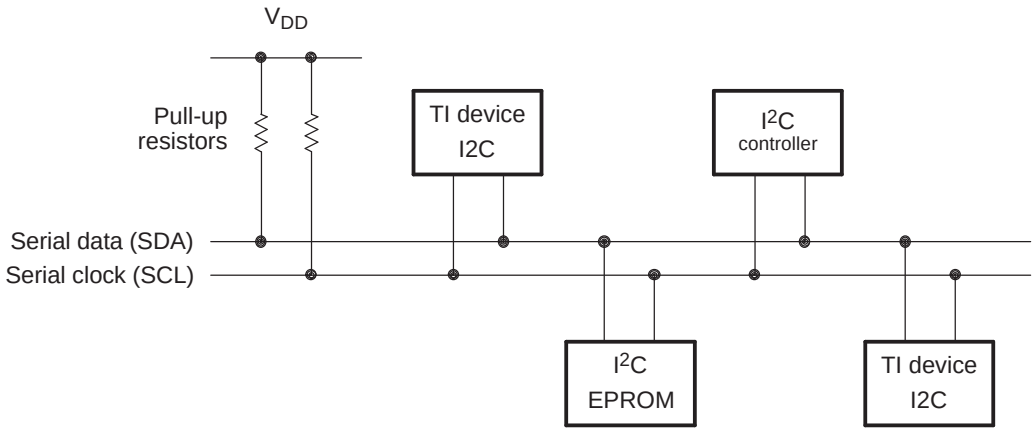
2.1 Bus Structure

Figure 1 shows how the I2C peripheral is connected to the I2C bus. The I2C bus is a multi-master bus that supports a multi-master mode. This allows more than one device capable of controlling the bus that is connected to it. A unique address recognizes each I2C device. Each I2C device can operate as either transmitter or receiver, depending on the function of the device. Devices that are connected to the I2C bus can be considered a master or slave when performing data transfers, in addition to being a transmitter or receiver.

Note: A master device is the device that initiates a data transfer on the bus and generates the clock signals to permit that transfer. Any device that is addressed by this master is considered a slave during this transfer.

An example of multiple I2C modules that are connected for a two-way transfer from one device to other devices is shown in Figure 2.

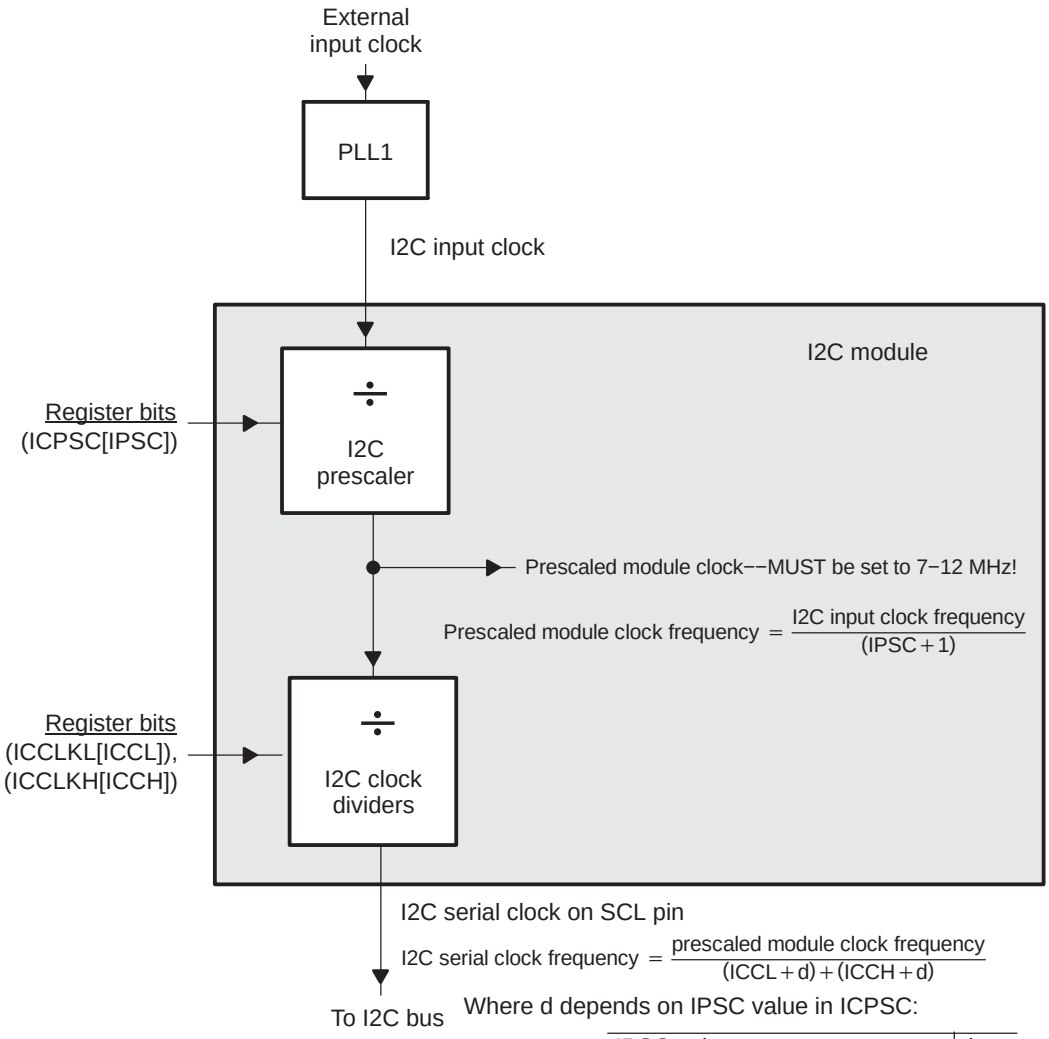
Figure 2. Multiple I2C Modules Connected



2.2 Clock Generation

As shown in Figure 3, PLL1 receives a signal from an external clock source and produces an I2C input clock. A programmable prescaler (IPSC bit in ICPSC) in the I2C module divides down the I2C input clock to produce a prescaled module clock. The prescaled module clock must be operated within the range of 7 to 12 MHz. The I2C clock dividers divide-down the high (ICCH bit in ICCLKH) and low portions (ICCL bit in ICCLKL) of the prescaled module clock signal to produce the I2C serial clock, which appears on the SCL pin when the I2C module is configured to be a master on the I2C bus.

Figure 3. Clocking Diagram for the I2C Peripheral



IPSC value	d
0	7
1	6
2h−FFh	5

CAUTION

Prescaled Module Clock Frequency Range:

The I2C module must be operated with a prescaled module clock frequency of 7 to 12 MHz. The I2C prescaler register (I2CPSC) must be configured to this frequency range.

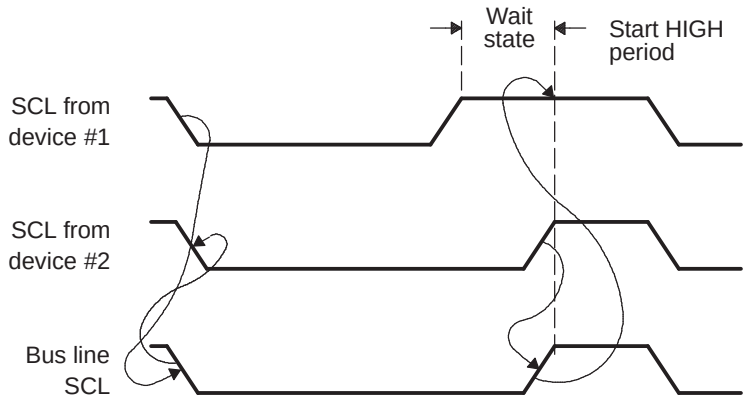
The prescaler (IPSC bit in ICPSC) must only be initialized while the I2C module is in the reset state (IRS = 0 in ICMDR). The prescaled frequency only takes effect when the IRS bit in ICMDR is changed to 1. Changing the IPSC bit in ICPSC while IRS = 1 in ICMDR has no effect. Likewise, you must configure the I2C clock dividers (ICCH bit in ICCLKH and ICCL bit in ICCLKL) while the I2C module is still in reset (IRS = 0 in ICMDR).

2.3 Clock Synchronization

Only one master device generates the clock signal (SCL) under normal conditions. However, there are two or more masters during the arbitration procedure; and, you must synchronize the clock so that you can compare the data output. Figure 4 illustrates the clock synchronization. The wired-AND property of SCL means that a device that first generates a low period on SCL (device #1) overrules the other devices. At this high-to-low transition, the clock generators of the other devices are forced to start their own low period. The SCL is held low by the device with the longest low period. The other devices that finish their low periods must wait for SCL to be released before starting their high periods. A synchronized signal on SCL is obtained, where the slowest device determines the length of the low period and the fastest device determines the length of the high period.

If a device pulls down the clock line for a longer time, the result is that all clock generators must enter the wait state. This way, a slave slows down a fast master and the slow device creates enough time to store a received data word or to prepare a data word that you are going to transmit.

Figure 4. Synchronization of Two I2C Clock Generators During Arbitration



2.4 Signal Descriptions

The I2C peripheral has a serial data pin (SDA) and a serial clock pin (SCL) for data communication, as shown in Figure 1. These two pins carry information between the DM357 device and other devices that are connected to the I2C-bus. The SDA and SCL pins both are bi-directional. They each must be connected to a positive supply voltage using a pull-up resistor. When the bus is free, both pins are high. The driver of these two pins has an open-drain configuration to perform the required wired-AND function.

See the device-specific data manual for additional timing and electrical specifications for these pins.

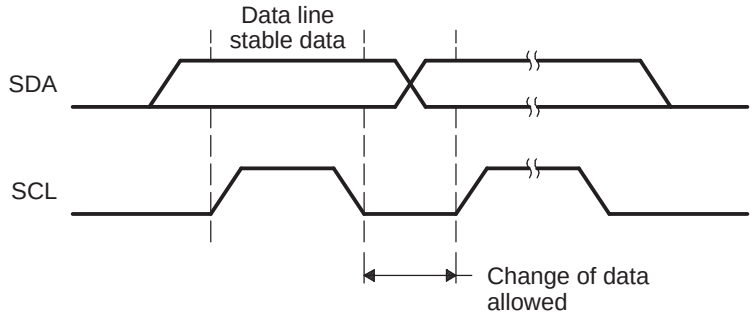
2.4.1 Input and Output Voltage Levels

The master device generates one clock pulse for each data bit that is transferred. Due to a variety of different technology devices that can be connected to the I2C-bus, the levels of logic 0 (low) and logic 1 (high) are not fixed and depend on the associated power supply level. See the device-specific data manual for more information.

2.4.2 Data Validity

The data on SDA must be stable during the high period of the clock (see Figure 5). The high or low state of the data line, SDA, can change only when the clock signal on SCL is low.

Figure 5. Bit Transfer on the I2C-Bus



2.5 START and STOP Conditions

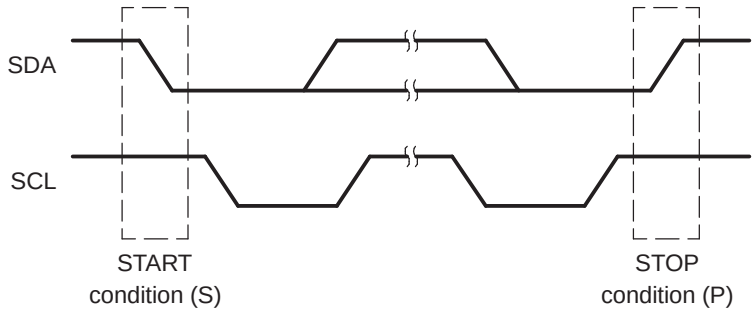
The I2C peripheral can generate START and STOP conditions when the peripheral is configured to be a master on the I2C-bus, as shown in Figure 6:

- The START condition is defined as a high-to-low transition on the SDA line while SCL is high. A master drives this condition to indicate the start of a data transfer.
- The STOP condition is defined as a low-to-high transition on the SDA line while SCL is high. A master drives this condition to indicate the end of a data transfer.

The I2C-bus is considered busy after a START condition and before a subsequent STOP condition. The bus busy (BB) bit of ICSTR is 1. The bus is considered free between a STOP condition and the next START condition. The BB is 0.

The master mode (MST) bit and the START condition (STT) bit in ICMDR must both be 1 for the I2C peripheral to start a data transfer with a START condition. The STOP condition (STP) bit must be set to 1 for the I2C peripheral to end a data transfer with a STOP condition. A repeated START condition generates when BB is set to 1 and STT is also set to 1. See Section 3.9 for a description of ICMDR (including the MST, STT, and STP bits).

Figure 6. I2C Peripheral START and STOP Conditions



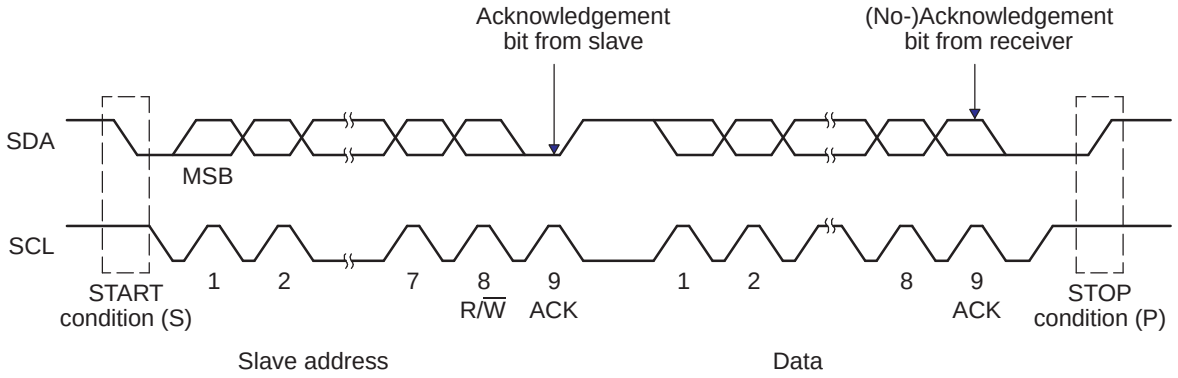
2.6 Serial Data Formats

Figure 7 shows an example of a data transfer on the I2C-bus. The I2C peripheral supports 1-bit to 8-bit data values. Figure 7 is shown in an 8-bit data format (BC = 000 in ICMDR). Each bit put on the SDA line is equivalent to one pulse on the SCL line. The data is always transferred with the most-significant bit (MSB) first. The number of data values that can be transmitted or received is unrestricted; however, the transmitters and receivers must agree on the number of data values being transferred.

The I2C peripheral supports the following data formats:

- 7-bit addressing mode
- 10-bit addressing mode
- Free data format mode

Figure 7. I2C Peripheral Data Transfer



2.6.1 7-Bit Addressing Format

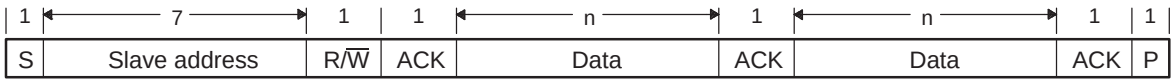
In the 7-bit addressing format (Figure 8), the first byte after a START condition (S) consists of a 7-bit slave address followed by a R/$\overline{W}$ bit. The R/$\overline{W}$ bit determines the direction of the data.

- R/$\overline{W}$ = 0: The master writes (transmits) data to the addressed slave.
- R/$\overline{W}$ = 1: The master reads (receives) data from the slave.

An extra clock cycle dedicated for acknowledgment (ACK) is inserted after the R/$\overline{W}$ bit. If the slave inserts the ACK bit, *n* bits of data from the transmitter (master or slave, depending on the R/$\overline{W}$ bit) follow it. *n* is a number from 1 to 8 that the bit count (BC) bits of ICMDR determine. The receiver inserts an ACK bit after the data bits have been transferred.

Write a 0 to the expanded address enable (XA) bit of ICMDR to select the 7-bit addressing format.

Figure 8. I2C Peripheral 7-Bit Addressing Format (FDF = 0, XA = 0 in ICMDR)



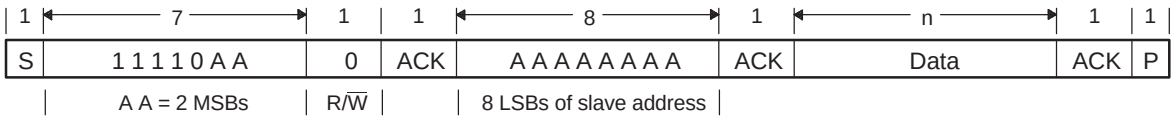
n = The number of data bits (from 1 to 8) specified by the bit count (BC) field of ICMDR.

2.6.2 10-Bit Addressing Format

The 10-bit addressing format (Figure 9) is like the 7-bit addressing format, but the master sends the slave address in two separate byte transfers. The first byte consists of 11110b, the two MSBs of the 10-bit slave address, and R/$\overline{W}$ = 0 (write). The second byte is the remaining 8 bits of the 10-bit slave address. The slave must send acknowledgment (ACK) after each of the two byte transfers. Once the master has written the second byte to the slave, the master can either write data or use a repeated START condition to change the data direction. (For more information about using 10-bit addressing, see the Philips Semiconductors I2C-bus specification.)

Write 1 to the XA bit of ICMDR to select the 10-bit addressing format.

Figure 9. I2C Peripheral 10-Bit Addressing Format With Master-Transmitter Writing to Slave-Receiver (FDF = 0, XA = 1 in ICMDR)



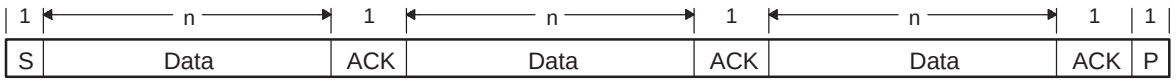
n = The number of data bits (from 1 to 8) specified by the bit count (BC) field of ICMDR.

2.6.3 Free Data Format

In the free data format (Figure 10), the first bits after a START condition (S) are a data word. An ACK bit is inserted after each data word, which can be from 1 to 8 bits, depending on the bit count (BC) bits of ICMDR. No address or data-direction bit is sent. Therefore, the transmitter and the receiver must both support the free data format, and the direction of the data must be constant throughout the transfer.

To select the free data format, write 1 to the free data format (FDF) bit of ICMDR.

Figure 10. I2C Peripheral Free Data Format (FDF = 1 in ICMDR)

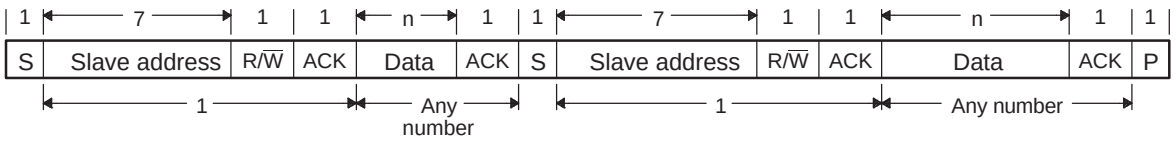


n = The number of data bits (from 1 to 8) specified by the bit count (BC) field of ICMDR.

2.6.4 Using a Repeated START Condition

The repeated START condition can be used with the 7-bit addressing, 10-bit addressing, and free data formats. The 7-bit addressing format using a repeated START condition (S) is shown in Figure 11. At the end of each data word, the master can drive another START condition. Using this capability, a master can transmit/receive any number of data words before driving a STOP condition. The length of a data word can be from 1 to 8 bits and is selected with the bit count (BC) bits of ICMDR.

Figure 11. I2C Peripheral 7-Bit Addressing Format With Repeated START Condition (FDF = 0, XA = 0 in ICMDR)



n = The number of data bits (from 1 to 8) specified by the bit count (BC) field of ICMDR.

2.7 Operating Modes

The I2C peripheral has four basic operating modes to support data transfers as a master and as a slave. See Table 1 for the names and descriptions of the modes.

If the I2C peripheral is a master, it begins as a master-transmitter and, typically, transmits an address for a particular slave. When giving data to the slave, the I2C peripheral must remain a master-transmitter. In order to receive data from a slave, the I2C peripheral must be changed to the master-receiver mode.

If the I2C peripheral is a slave, it begins as a slave-receiver and, typically, sends acknowledgment when it recognizes its slave address from a master. If the master will be sending data to the I2C peripheral, the peripheral must remain a slave-receiver. If the master has requested data from the I2C peripheral, the peripheral must be changed to the slave-transmitter mode.

Table 1. Operating Modes of the I2C Peripheral

Operating Mode	Description
Slave-receiver mode	The I2C peripheral is a slave and receives data from a master. All slave modules begin in this mode. In this mode, serial data bits received on SDA are shifted in with the clock pulses that are generated by the master. As a slave, the I2C peripheral does not generate the clock signal, but it can hold SCL low while the intervention of the processor is required (RSFULL = 1 in ICSTR) after data has been received.
Slave-transmitter mode	The I2C peripheral is a slave and transmits data to a master. This mode can only be entered from the slave-receiver mode; the I2C peripheral must first receive a command from the master. When you are using any of the 7-bit/10-bit addressing formats, the I2C peripheral enters its slave-transmitter mode if the slave address is the same as its own address (in ICOAR) and the master has transmitted R/$\overline{W}$ = 1. As a slave-transmitter, the I2C peripheral then shifts the serial data out on SDA with the clock pulses that are generated by the master. While a slave, the I2C peripheral does not generate the clock signal, but it can hold SCL low while the intervention of the processor is required (XSMT = 0 in ICSTR) after data has been transmitted.
Master-receiver mode	The I2C peripheral is a master and receives data from a slave. This mode can only be entered from the master-transmitter mode; the I2C peripheral must first transmit a command to the slave. When you are using any of the 7-bit/10-bit addressing formats, the I2C peripheral enters its master-receiver mode after transmitting the slave address and R/$\overline{W}$ = 1. Serial data bits on SDA are shifted into the I2C peripheral with the clock pulses generated by the I2C peripheral on SCL. The clock pulses are inhibited and SCL is held low when the intervention of the processor is required (RSFULL = 1 in ICSTR) after data has been received.
Master-transmitter mode	The I2C peripheral is a master and transmits control information and data to a slave. All master modules begin in this mode. In this mode, data assembled in any of the 7-bit/10-bit addressing formats is shifted out on SDA. The bit shifting is synchronized with the clock pulses generated by the I2C peripheral on SCL. The clock pulses are inhibited and SCL is held low when the intervention of the processor is required (XSMT = 0 in ICSTR) after data has been transmitted.

2.8 NACK Bit Generation

When the I2C peripheral is a receiver (master or slave), it can acknowledge or ignore bits sent by the transmitter. To ignore any new bits, the I2C peripheral must send a no-acknowledge (NACK) bit during the acknowledge cycle on the bus. Table 2 summarizes the various ways the I2C peripheral sends a NACK bit.

Table 2. Ways to Generate a NACK Bit

	NACK Bit Generation	
I2C Peripheral Condition	**Basic**	**Optional**
Slave-receiver mode	• Disable data transfers (STT = 0 in ICSTR). • Allow an overrun condition (RSFULL = 1 in ICSTR). • Reset the peripheral (IRS = 0 in ICMDR) .	Set the NACKMOD bit of ICMDR before the rising edge of the last data bit you intend to receive.
Master-receiver mode AND Repeat mode (RM = 1 in ICMDR)	• Generate a STOP condition (STOP = 1 in ICMDR). • Reset the peripheral (IRS = 0 in ICMDR).	Set the NACKMOD bit of ICMDR before the rising edge of the last data bit you intend to receive.
Master-receiver mode AND Nonrepeat mode (RM = 0 in ICMDR)	• If STP = 1 in ICMDR, allow the internal data counter to count down to 0 and force a STOP condition. • If STP = 0, make STP = 1 to generate a STOP condition. • Reset the peripheral (IRS = 0 in ICMDR).	Set the NACKMOD bit of ICMDR before the rising edge of the last data bit you intend to receive.

2.9 Arbitration

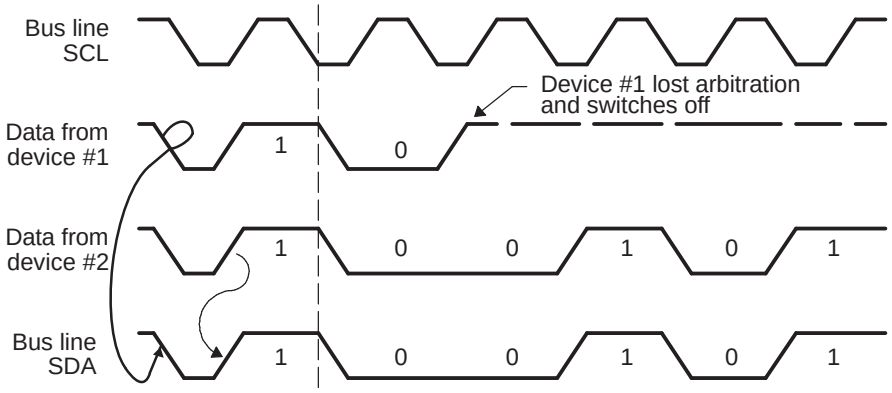
If two or more master-transmitters simultaneously start a transmission on the same bus, an arbitration procedure is invoked. The arbitration procedure uses the data presented on the serial data bus (SDA) by the competing transmitters. Figure 12 illustrates the arbitration procedure between two devices. The first master-transmitter, which drives SDA high, is overruled by another master-transmitter that drives SDA low. The arbitration procedure gives priority to the device that transmits the serial data stream with the lowest binary value. Should two or more devices send identical first bytes, arbitration continues on the subsequent bytes.

If the I2C peripheral is the losing master, it switches to the slave-receiver mode, sets the arbitration lost (AL) flag, and generates the arbitration-lost interrupt.

If during a serial transfer the arbitration procedure is still in progress when a repeated START condition or a STOP condition is transmitted to SDA, the master-transmitters involved must send the repeated START condition or the STOP condition at the same position in the format frame. Arbitration is not allowed between:

- A repeated START condition and a data bit
- A STOP condition and a data bit
- A repeated START condition and a STOP condition

Figure 12. Arbitration Procedure Between Two Master-Transmitters



2.10 Reset Considerations

The I2C peripheral has two reset sources: software reset and hardware reset.

2.10.1 Software Reset Considerations

To reset the I2C peripheral, write 0 to the I2C reset (IRS) bit in the I2C mode register (ICMDR). All status bits in the I2C interrupt status register (ICSTR) are forced to their default values, and the I2C peripheral remains disabled until IRS is changed to 1. The SDA and SCL pins are in the high-impedance state.

Note: If the IRS bit is cleared to 0 during a transfer, this can cause the I2C bus to hang (SDA and SCL are in the high-impedance state).

2.10.2 Hardware Reset Considerations

When a hardware reset occurs, all the registers of the I2C peripheral are set to their default values and the I2C peripheral remains disabled until the I2C reset (IRS) bit in the I2C mode register (ICMDR) is changed to 1.

Note: The IRS bit must be cleared to 0 while you configure/reconfigure the I2C peripheral. Forcing IRS to 0 can be used to save power and to clear error conditions.

2.11 Initialization

Proper I2C initialization is required prior to starting communication with other I2C device(s). Unless a fully fledged driver is in place, you need to determine the required I2C configuration needed (for example, Master Receiver, etc.) and configure the I2C controller with the desired settings. Enabling the I2C clock should be the first task. Then the I2C controller is placed in reset. You now are ready to configure the I2C controller. Once configuration is done, you need to enable the I2C controller by releasing the controller from reset. Prior to starting communication, you need to make sure that all status bits are cleared and no pending interrupts exist. Once the bus is determined to be available (the bus is not busy), the I2C is ready to proceed with the desired communication.

2.11.1 Configuring the I2C in Master Receiver Mode and Servicing Receive Data via CPU

The following initialization procedure is for the I2C controller configured in Master Receiver mode. The CPU is used to move data from the I2C receive register to CPU memory (memory accessible by the CPU).

1. Enable I2C clock from the Power and Sleep Controller (see the *TMS320DM357 DMSoC ARM Subsystem Reference Guide* (SPRUG25).
2. Place I2C in reset (clear IRS = 0 in ICMDR).
3. Configure ICMDR:
   - Configure I2C as Master (MST = 1).
   - Indicate the I2C configuration to be used; for example, Data Receiver (TRX = 0)
   - Indicate 7-bit addressing is to be used (XA = 0).
   - Disable repeat mode (RM = 0).
   - Disable loopback mode (DLB = 0).
   - Disable free data format (FDF = 0).
   - Optional: Disable start byte mode if addressing a fully fledged I2C device (STB = 0).
   - Set number of bits to transfer to be 8 bits (BC = 0).
4. Configure Slave Address: the I2C device this I2C master would be addressing (ICSAR = 7BIT ADDRESS).
5. Configure the peripheral clock operation frequency (ICPSC). This value should be selected in such a way that the frequency is between 7 and 12 MHZ.
6. Configure I2C master clock frequency:
   - Configure the low-time divider value (ICCLKL).
   - Configure the high-time divider value (ICCLKH).
7. Make sure the interrupt status register (ICSTR) is cleared:
   - Read ICSTR and write it back (write 1 to clear) ICSTR = ICSTR
   - Read ICIVR until it is zero.
8. Take I2C controller out of reset: enable I2C controller (set IRS bit = 1 in ICMDR).
9. Wait until bus busy bit is cleared (BB = 0 in ICSTR).
10. Generate a START event, followed by Slave Address, etc. (set STT = 1 in ICMDR).
11. Wait until data is received (ICRRDY = 1 in ICSTR).
12. Read data:
    - If ICRRDY = 1 in ICSTR, then read ICDRR.
    - Perform the previous two steps until receiving one byte short of the entire byte expecting to receive.
13. Configure the I2C controller not to generate an ACK on the next/final byte reception: set NACKMOD bit for the I2C to generate a NACK on the last byte received (set NACKMOD = 1 in ICMDR).
14. End transfer/release bus when transfer is done. Generate a STOP event (set STP = 1 in ICMDR).

2.11.2 Configuring the I2C in Slave Receiver and Transmitter Mode

The following initialization procedure is for the I2C controller configured in Slave Receiver and Transmitter mode.

1. Enable I2C clock from PSC Level. Do this so that you will be able to configure the I2C registers.
2. Place I2C in Reset (Clear IRS bit).
   - IRS=0
3. Assign the Address (a 7 bit or 10 bit address) that the I2C Controller will be responding to. This is the Address that the Master is going to broadcast when attempting to start communication with this slave device; I2C Controller.
   - If the I2C is able to respond to 7-bit Addressing: Configure XA=0
   - If the I2C is able to respond to 10-bit Addressing: Configure XA=1
   - Program ICOAR=Assigned Address(7 or 10 bit Address)
4. Enable the desired interrupt you need to receive by setting the desired interrupt bit field within ICIMR to enable the particular Interrupt.

- AAS=1; Expect an interrupt when Master's Address matches yours (ICOAR programmed value).
- ICRRDY=1; Expect a receive interrupt when a byte worth data sent from the master is ready to be read.
- ICXRDY=1; Expect to receive interrupt when the transmit register is ready to be written with a new data that is to be sent to the master.
- SCD=1; Expect to receive interrupt when Stop Condition is detected.

5. Configure the I2C Controller Operating frequency; this is not the serial clock frequency. This should be between 7 and 12 MHz. Program IPSC to generate a 7 to 12MHz operating frequency.
   - Prescaled Module Clock Frequency = PLL1 Output Frequency / (IPSC + 1).
6. Configure the I2C Serial Clock Frequency. It is advised to configure this frequency to operate at 400 KHz. This will allow the slave device to be able to attend to all Master speeds. Program ICCH and ICCL.
   - 400 KHz = I2C Operating Frequency (7-12MHz from Step 5) / [(ICCH+5) + (ICCL+5)].
   - If ICCL==ICCH ≥ 400 KHz = Prescaled Module Clock Frequency / [2×ICCH+10]
7. Configure the Mode Register.
   - MST=0; Configure the I2C Controller to operate as SLAVE.
   - FDF=0; Free Data Format is disabled.
   - BC=0; Set data width to 8 bytes.
   - DLB=0; Disable Loopback Mode.
   - STB=0; I2C Controller can detect Start condition via H/W.
   - RM=1, STP=0, STT=1. See Table 16. (No Activity case).
   - Configure remaining bits other than IRS to 0.
8. Release I2C from Reset
   - IRS=1; Make sure you do not over write your previous configurations.
9. Make sure Interrupt Status Register is cleared.
   - ICSTR=ICSTR; Clear Interrupt fields that require writing '1' requirements.
   - While (ICIVR != 0) Read ICIVR; Read until it is cleared to Zero.
10. Instruct I2C Controller to detect START Condition and Its Own Address.
    - STT=1; Make sure you do not over write your previous configurations.

    MASTER desires to perform a write transfer.
11. If Master requests a Write, i.e, I2C needs to receive data, perform the following.
    - Wait for Receive Interrupt to be received, i.e, ICRRDY=1.
    - Read Data
12. Perform Step 11 until one of the two happens:
    - Master generates a STOP Condition (SCD=1) or
    - I2C Slave desires to end receive transfer.

      If the latter, then the I2C needs to Not Acknowledge the last byte to be received from the Master. After reading the byte prior from the last byte set NACKMOD bit so that the I2C automatically NACKs the following received data byte, which is the last data byte.
    - NACKMOD=1; set this field on the 2nd data prior from the last.

    Master desires to perform a read transfer.
13. If Master requests a Read, i.e, I2C needs to transmit data, perform the following.
    - Write Data.
    - Wait for Transmit Interrupt to be received, i.e, ICXRDY=1.
14. Perform step 13 until a STOP condition is detected, i.e. (SCD=1).

2.12 Interrupt Support

The I2C peripheral is capable of interrupting the ARM CPU. The CPU can determine which I2C events caused the interrupt by reading the I2C interrupt vector register (ICIVR). ICIVR contains a binary-coded interrupt vector type to indicate which interrupt has occurred. Reading ICIVR clears the interrupt flag; if other interrupts are pending, a new interrupt is generated. If there is more than one pending interrupt flag, reading ICIVR clears the highest-priority interrupt flag.

2.12.1 Interrupt Events and Requests

The I2C peripheral can generate the interrupts described in Table 3. Each interrupt has a flag bit in the I2C interrupt status register (ICSTR) and a mask bit in the interrupt mask register (ICIMR). When one of the specified events occurs, its flag bit is set. If the corresponding mask bit is 0, the interrupt request is blocked; if the mask bit is 1, the request is forwarded to the CPU as an I2C interrupt.

Table 3. Descriptions of the I2C Interrupt Events

I2C Interrupt	Initiating Event
Arbitration-lost interrupt (AL)	Generated when the I2C arbitration procedure is lost or illegal START/STOP conditions occur
No-acknowledge interrupt (NACK)	Generated when the master I2C does not receive any acknowledge from the receiver
Registers-ready-for-access interrupt (ARDY)	Generated by the I2C when the previously programmed address, data and command have been performed and the status bits have been updated. This interrupt is used to let the controlling processor know that the I2C registers are ready to be accessed.
Receive interrupt/status (ICRINT and ICRRDY)	Generated when the received data in the receive-shift register (ICRSR) has been copied into the ICDRR. The ICRRDY bit can also be polled by the CPU to read the received data in the ICDRR.
Transmit interrupt/status (ICXINT and ICXRDY)	Generated when the transmitted data has been copied from ICDXR to the transmit-shift register (ICXSR) and shifted out on the SDA pin. This bit can also polled by the CPU to write the next transmitted data into the ICDXR.
Stop-Condition-Detection interrupt (SCD)	Generated when a STOP condition has been detected
Address-as-Slave interrupt (AAS)	Generated when the I2C has recognized its own slave address or an address of all (8) zeros.

2.12.2 Interrupt Multiplexing

The I2C interrupt to the ARM CPU are not multiplexed with any other interrupt source.

2.13 DMA Events Generated by the I2C Peripheral

For the EDMA controller to handle transmit and receive data, the I2C peripheral generates the following two EDMA events. Activity in EDMA channels can be synchronized to these events.

- Receive event (ICREVT): When receive data has been copied from the receive shift register (ICRSR) to the data receive register (ICDRR), the I2C peripheral sends an REVT signal to the EDMA controller. In response, the EDMA controller can read the data from ICDRR.
- Transmit event (ICXEVT): When transmit data has been copied from the data transmit register (ICDXR) to the transmit shift register (ICXSR), the I2C peripheral sends an XEVT signal to the EDMA controller. In response, the EDMA controller can write the next transmit data value to ICDXR.

2.14 Power Management

The I2C peripheral can be placed in reduced-power modes to conserve power during periods of low activity. The power management of the I2C peripheral is controlled by the processor Power and Sleep Controller (PSC). The PSC acts as a master controller for power management for all of the peripherals on the device. For detailed information on power management procedures using the PSC, see the *TMS320DM357 DMSoC ARM Subsystem Reference Guide* (SPRUG25).

2.15 Emulation Considerations

The response of the I2C events to emulation suspend events (such as halts and breakpoints) is controlled by the FREE bit in the I2C mode register (ICMDR). The I2C peripheral either stops exchanging data (FREE = 0) or continues to run (FREE = 1) when an emulation suspend event occurs. How the I2C peripheral terminates data transactions is affected by whether the I2C peripheral is acting as a master or a slave. For more information, see the description of the FREE bit in ICMDR (see Section 3.9).

3 Registers

Table 4 lists the memory-mapped registers for the inter-integrated circuit (I2C) peripheral. See the device-specific data manual for the memory address of these registers. All other register offset addresses not listed in Table 4 should be considered as reserved locations and the register contents should not be modified.

Table 4. Inter-Integrated Circuit (I2C) Registers

Offset	Acronym	Register Description	Section
0h	ICOAR	I2C Own Address Register	Section 3.1
4h	ICIMR	I2C Interrupt Mask Register	Section 3.2
8h	ICSTR	I2C Interrupt Status Register	Section 3.3
Ch	ICCLKL	I2C Clock Low-Time Divider Register	Section 3.4
10h	ICCLKH	I2C Clock High-Time Divider Register	Section 3.4
14h	ICCNT	I2C Data Count Register	Section 3.5
18h	ICDRR	I2C Data Receive Register	Section 3.6
1Ch	ICSAR	I2C Slave Address Register	Section 3.7
20h	ICDXR	I2C Data Transmit Register	Section 3.8
24h	ICMDR	I2C Mode Register	Section 3.9
28h	ICIVR	I2C Interrupt Vector Register	Section 3.10
2Ch	ICEMDR	I2C Extended Mode Register	Section 3.11
30h	ICPSC	I2C Prescaler Register	Section 3.12
34h	ICPID1	I2C Peripheral Identification Register 1	Section 3.13
38h	ICPID2	I2C Peripheral Identification Register 2	Section 3.13

3.1 I2C Own Address Register (ICOAR)

The I2C own address register (ICOAR) is used to specify its own slave address, which distinguishes it from other slaves connected to the I2C-bus. If the 7-bit addressing mode is selected (XA = 0 in ICMDR), only bits 6-0 are used; bits 9-7 are ignored.

The I2C own address register (ICOAR) is shown in Figure 13 and described in Table 5.

Figure 13. I2C Own Address Register (ICOAR)

31	16
Reserved	
R-0	

15	10	9	0
Reserved		OADDR	
R-0		R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 5. I2C Own Address Register (ICOAR) Field Descriptions

Bit	Field	Value	Description
31-10	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
9-0	OADDR	0-3FFh	Own slave address. Provides the slave address of the I2C. In 7-bit addressing mode (XA = 0 in ICMDR): bits 6-0 provide the 7-bit slave address of the I2C. Bits 9-7 are ignored. In 10-bit addressing mode (XA = 1 in ICMDR): bits 9-0 provide the 10-bit slave address of the I2C.

3.2 I2C Interrupt Mask Register (ICIMR)

The I2C interrupt mask register (ICIMR) is used to individually enable or disable I2C interrupt requests.

The I2C interrupt mask register (ICIMR) is shown in Figure 14 and described Table 6.

Figure 14. I2C Interrupt Mask Register (ICIMR)

31							8
Reserved							
R-0							

7	6	5	4	3	2	1	0
Reserved	AAS	SCD	ICXRDY	ICRRDY	ARDY	NACK	AL
R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 6. I2C Interrupt Mask Register (ICIMR) Field Descriptions

Bit	Field	Value	Description
31-7	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
6	AAS		Address-as-slave interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
5	SCD		Stop condition detected interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
4	ICXRDY		Transmit-data-ready interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
3	ICRRDY		Receive-data-ready interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
2	ARDY		Register-access-ready interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
1	NACK		No-acknowledgment interrupt enable bit.
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.
0	AL		Arbitration-lost interrupt enable bit
		0	Interrupt request is disabled.
		1	Interrupt request is enabled.

3.3 I2C Interrupt Status Register (ICSTR)

The I2C interrupt status register (ICSTR) is used to determine which interrupt has occurred and to read status information.

The I2C interrupt status register (ICSTR) is shown in Figure 15 and described in Table 7.

Figure 15. I2C Interrupt Status Register (ICSTR)

31							16
Reserved							
R-0							

15	14	13	12	11	10	9	8
Reserved	SDIR	NACKSNT	BB	RSFULL	XSMT	AAS	AD0
R-0	R/W1C-0	R/W1C-0	R/W1C-0	R-0	R-1	R-0	R-0

7	6	5	4	3	2	1	0
Reserved		SCD	ICXRDY	ICRRDY	ARDY	NACK	AL
R-0		R/W1C-0	R/W1C-1	R/W1C-0	R/W1C-0	R/W1C-0	R/W1C-0

LEGEND: R/W = Read/Write; R = Read only; W1C = Write 1 to clear (writing 0 has no effect); -*n* = value after reset

Table 7. I2C Interrupt Status Register (ICSTR) Field Descriptions

Bit	Field	Value	Description
31-15	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
14	SDIR		Slave direction bit. In digital-loopback mode (DLB), the SDIR bit is cleared to 0.
		0	I2C is acting as a master-transmitter/receiver or a slave-receiver. SDIR is cleared by one of the following events: • A STOP or a START condition. • SDIR is manually cleared. To clear this bit, write a 1 to it.
		1	I2C is acting as a slave-transmitter.
13	NACKSNT		No-acknowledgment sent bit. NACKSNT bit is used when the I2C is in the receiver mode. One instance in which NACKSNT is affected is when the NACK mode is used (see the description for NACKMOD in Section 3.9).
		0	NACK is not sent. NACKSNT is cleared by one of the following events: • It is manually cleared. To clear this bit, write a 1 to it. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	NACK is sent. A no-acknowledge bit was sent during the acknowledge cycle on the I2C-bus.
12	BB		Bus busy bit. BB bit indicates whether the I2C-bus is busy or is free for another data transfer. In the master mode, BB is controlled by the software.
		0	Bus is free. BB is cleared by one of the following events: • The I2C receives or transmits a STOP bit (bus free). • BB is manually cleared. To clear this bit, write a 1 to it. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	Bus is busy. When the STT bit in ICMDR is set to 1, a restart condition is generated. BB is set by one of the following events: • The I2C has received or transmitted a START bit on the bus. • SCL is in a low state and the IRS bit in ICMDR is 0.

Table 7. I2C Interrupt Status Register (ICSTR) Field Descriptions (continued)

Bit	Field	Value	Description
11	RSFULL		Receive shift register full bit. RSFULL indicates an overrun condition during reception. Overrun occurs when the receive shift register (ICRSR) is full with new data but the previous data has not been read from the data receive register (ICDRR). The new data will not be copied to ICDRR until the previous data is read. As new bits arrive from the SDA pin, they overwrite the bits in ICRSR.
		0	No overrun is detected. RSFULL is cleared by one of the following events: • ICDRR is read. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	Overrun is detected.
10	XSMT		Transmit shift register empty bit. XSMT indicates that the transmitter has experienced underflow. Underflow occurs when the transmit shift register (ICXSR) is empty but the data transmit register (ICDXR) has not been loaded since the last ICDXR-to-ICXSR transfer. The next ICDXR-to-ICXSR transfer will not occur until new data is in ICDXR. If new data is not transferred in time, the previous data may be re-transmitted on the SDA pin.
		0	Underflow is detected.
		1	No underflow is detected. XSMT is set by one of the following events: • Data is written to ICDXR. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
9	AAS		Addressed-as-slave bit.
		0	The AAS bit has been cleared by a repeated START condition or by a STOP condition.
		1	AAS is set by one of the following events: • I2C has recognized its own slave address or an address of all zeros (general call). • The first data word has been received in the free data format (FDF = 1 in ICMDR).
8	AD0		Address 0 bit.
		0	AD0 has been cleared by a START or STOP condition.
		1	An address of all zeros (general call) is detected.
7-6	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
5	SCD		Stop condition detected bit. SCD indicates when a STOP condition has been detected on the I2C bus. The STOP condition could be generated by the I2C or by another I2C device connected to the bus.
		0	No STOP condition has been detected. SCD is cleared by one of the following events: • By reading the INTCODE bits in ICIVR as 110b. • SCD is manually cleared. To clear this bit, write a 1 to it.
		1	A STOP condition has been detected.
4	ICXRDY		Transmit-data-ready interrupt flag bit. ICXRDY indicates that the data transmit register (ICDXR) is ready to accept new data because the previous data has been copied from ICDXR to the transmit shift register (ICXSR). The CPU can poll ICXRDY or use the XRDY interrupt request.
		0	ICDXR is not ready. ICXRDY is cleared by one of the following events: • Data is written to ICDXR. • ICXRDY is manually cleared. To clear this bit, write a 1 to it.
		1	ICDXR is ready. Data has been copied from ICDXR to ICXSR. ICXRDY is forced to 1 when the I2C is reset.
3	ICRRDY		Receive-data-ready interrupt flag bit. ICRRDY indicates that the data receive register (ICDRR) is ready to be read because data has been copied from the receive shift register (ICRSR) to ICDRR. The CPU can poll ICRRDY or use the RRDY interrupt request.
		0	ICDRR is not ready. ICRRDY is cleared by one of the following events: • ICDRR is read. • ICRRDY is manually cleared. To clear this bit, write a 1 to it. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	ICDRR is ready. Data has been copied from ICRSR to ICDRR.

Table 7. I2C Interrupt Status Register (ICSTR) Field Descriptions (continued)

Bit	Field	Value	Description
2	ARDY		Register-access-ready interrupt flag bit (only applicable when the I2C is in the master mode). ARDY indicates that the I2C registers are ready to be accessed because the previously programmed address, data, and command values have been used. The CPU can poll ARDY or use the ARDY interrupt request.
		0	The registers are not ready to be accessed. ARDY is cleared by one of the following events: • The I2C starts using the current register contents. • ARDY is manually cleared. To clear this bit, write a 1 to it. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	The registers are ready to be accessed. • In the nonrepeat mode (RM = 0 in ICMDR): If STP = 0 in ICMDR, ARDY is set when the internal data counter counts down to 0. If STP = 1, ARDY is not affected (instead, the I2C generates a STOP condition when the counter reaches 0). • In the repeat mode (RM = 1): ARDY is set at the end of each data word transmitted from ICDXR.
1	NACK		No-acknowledgment interrupt flag bit. NACK applies when the I2C is a transmitter (master or slave). NACK indicates whether the I2C has detected an acknowledge bit (ACK) or a no-acknowledge bit (NACK) from the receiver. The CPU can poll NACK or use the NACK interrupt request.
		0	ACK received/NACK is not received. NACK is cleared by one of the following events: • An acknowledge bit (ACK) has been sent by the receiver. • NACK is manually cleared. To clear this bit, write a 1 to it. • The CPU reads the interrupt source register (ICISR) when the register contains the code for a NACK interrupt. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	NACK bit is received. The hardware detects that a no-acknowledge (NACK) bit has been received. **Note:** While the I2C performs a general call transfer, NACK is 1, even if one or more slaves send acknowledgment.
0	AL		Arbitration-lost interrupt flag bit (only applicable when the I2C is a master-transmitter). AL primarily indicates when the I2C has lost an arbitration contest with another master-transmitter. The CPU can poll AL or use the AL interrupt request.
		0	Arbitration is not lost. AL is cleared by one of the following events: • AL is manually cleared. To clear this bit, write a 1 to it. • The CPU reads the interrupt source register (ICISR) when the register contains the code for an AL interrupt. • The I2C is reset (either when 0 is written to the IRS bit of ICMDR or when the processor is reset).
		1	Arbitration is lost. AL is set by one of the following events: • The I2C senses that it has lost an arbitration with two or more competing transmitters that started a transmission almost simultaneously. • The I2C attempts to start a transfer while the BB (bus busy) bit is set to 1. When AL is set to 1, the MST and STP bits of ICMDR are cleared, and the I2C becomes a slave-receiver.

3.4 I2C Clock Divider Registers (ICCLKL and ICCLKH)

When the I2C is a master, the prescaled module clock is divided down for use as the I2C serial clock on the SCL pin. The shape of the I2C serial clock depends on two divide-down values, ICCL and ICCH. For detailed information on how these values are programmed, see Section 2.2.

3.4.1 I2C Clock Low-Time Divider Register (ICCLKL)

For each I2C serial clock cycle, ICCL determines the amount of time the signal is low. ICCLKL must be configured while the I2C is still in reset (IRS = 0 in ICMDR).

The I2C clock low-time divider register (ICCLKL) is shown in Figure 16 and described in Table 8.

Figure 16. I2C Clock Low-Time Divider Register (ICCLKL)

31	16
Reserved	
R-0	

15	0
ICCL	
R/W-0	

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 8. I2C Clock Low-Time Divider Register (ICCLKL) Field Descriptions

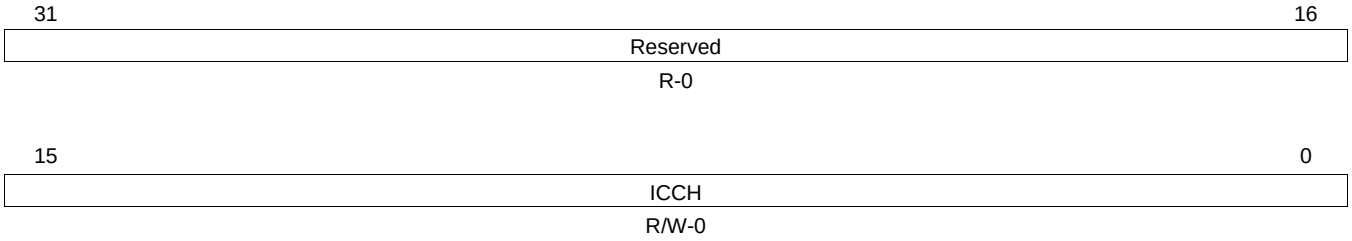
Bit	Field	Value	Description
31-16	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
15-0	ICCL	0-FFFFh	Clock low-time divide-down value of 1-65536. The period of the module clock is multiplied by (ICCL + d) to produce the low-time duration of the I2C serial on the SCL pin.

3.4.2 I2C Clock High-Time Divider Register (ICCLKH)

For each I2C serial clock cycle, ICCH determines the amount of time the signal is high. ICCLKH must be configured while the I2C is still in reset (IRS = 0 in ICMDR).

The I2C clock high-time divider register (ICCLKH) is shown in Figure 17 and described in Table 9.

Figure 17. I2C Clock High-Time Divider Register (ICCLKH)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 9. I2C Clock High-Time Divider Register (ICCLKH) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
15-0	ICCH	0-FFFFh	Clock high-time divide-down value of 1-65536. The period of the module clock is multiplied by (ICCH + d) to produce the high-time duration of the I2C serial on the SCL pin.

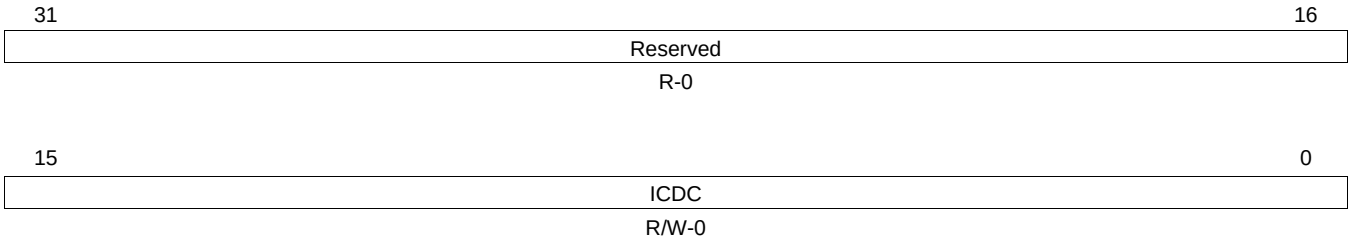
3.5 I2C Data Count Register (ICCNT)

The I2C data count register (ICCNT) is used to indicate how many data words to transfer when the I2C is configured as a master-transmitter (MST = 1 and TRX = 1 in ICMDR) and the repeat mode is off (RM = 0 in ICMDR). In the repeat mode (RM = 1), ICCNT is not used.

The value written to ICCNT is copied to an internal data counter. The internal data counter is decremented by 1 for each data word transferred (ICCNT remains unchanged). If a STOP condition is requested (STP = 1 in ICMDR), the I2C terminates the transfer with a STOP condition when the countdown is complete (that is, when the last data word has been transferred).

The data count register (ICCNT) is shown in Figure 18 and described in Table 10.

Figure 18. I2C Data Count Register (ICCNT)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 10. I2C Data Count Register (ICCNT) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
15-0	ICDC	0-FFFFh	Data count value. When RM = 0 in ICMDR, ICDC indicates the number of data words to transfer in the nonrepeat mode. When RM = 1 in ICMDR, the value in ICCNT is a don't care. If STP = 1 in ICMDR, a STOP condition is generated when the internal data counter counts down to 0.
		0	The start value loaded to the internal data counter is 65536.
		1h-FFFFh	The start value loaded to internal data counter is 1-65535.

3.6 I2C Data Receive Register (ICDRR)

The I2C data receive register (ICDRR) is used to read the receive data. The ICDRR can receive a data value of up to 8 bits; data values with fewer than 8 bits are right-aligned in the D bits and the remaining D bits are undefined. The number of data bits is selected by the bit count bits (BC) of ICMDR. The I2C receive shift register (ICRSR) shifts in the received data from the SDA pin. Once data is complete, the I2C copies the contents of ICRSR into ICDRR. The CPU and the EDMA controller cannot access ICRSR.

The I2C data receive register (ICDRR) is shown in Figure 19 and described in Table 11.

Figure 19. I2C Data Receive Register (ICDRR)

31	16
Reserved	
R-0	

15	8	7	0
Reserved		D	
R-0		R-0	

LEGEND: R = Read only; -*n* = value after reset

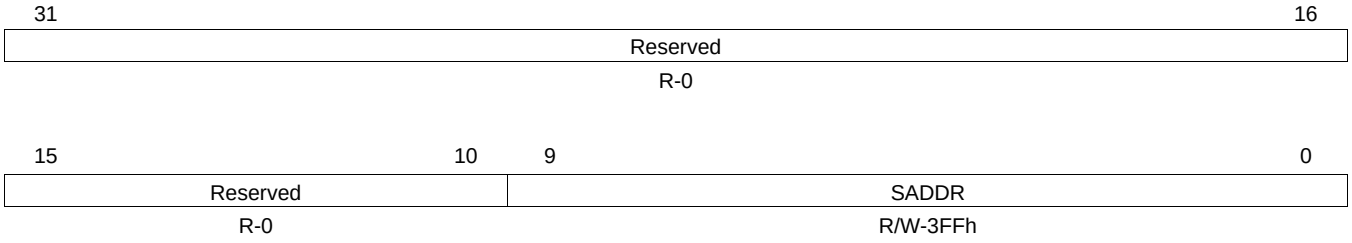
Table 11. I2C Data Receive Register (ICDRR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
7-0	D	0-FFh	Receive data.

3.7 I2C Slave Address Register (ICSAR)

The I2C slave address register (ICSAR) contains a 7-bit or 10-bit slave address. When the I2C is not using the free data format (FDF = 0 in ICMDR), it uses this address to initiate data transfers with a slave or slaves. When the address is nonzero, the address is for a particular slave. When the address is 0, the address is a general call to all slaves. If the 7-bit addressing mode is selected (XA = 0 in ICMDR), only bits 6-0 of ICSAR are used; bits 9-7 are ignored. The I2C slave address register (ICSAR) is shown in Figure 20 and described in Table 12.

Figure 20. I2C Slave Address Register (ICSAR)



LEGEND: R/W = Read/Write; R = Read only; *-n* = value after reset

Table 12. I2C Slave Address Register (ICSAR) Field Descriptions

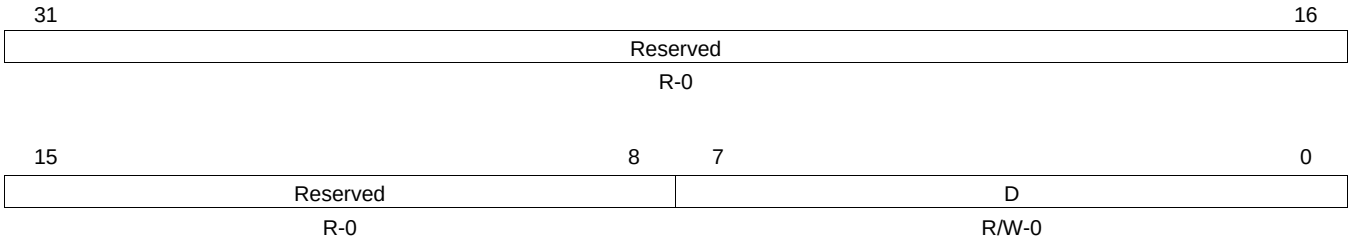
Bit	Field	Value	Description
31-10	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
9-0	SADDR	0-3FFh	Slave address. Provides the slave address of the I2C. In 7-bit addressing mode (XA = 0 in ICMDR): bits 6-0 provide the 7-bit slave address that the I2C transmits when it is in the master-transmitter mode. Bits 9-7 are ignored. In 10-bit addressing mode (XA = 1 in ICMDR): Bits 9-0 provide the 10-bit slave address that the I2C transmits when it is in the master-transmitter mode.

3.8 I2C Data Transmit Register (ICDXR)

The CPU or EDMA writes transmit data to the I2C data transmit register (ICDXR). The ICDXR can accept a data value of up to 8 bits. When writing a data value with fewer than 8 bits, the written data must be right-aligned in the D bits. The number of data bits is selected by the bit count bits (BC) of ICMDR. Once data is written to ICDXR, the I2C copies the contents of ICDXR into the I2C transmit shift register (ICXSR). The ICXSR shifts out the transmit data from the SDA pin. The CPU and the EDMA controller cannot access ICXSR.

The I2C data transmit register (ICDXR) is shown in Figure 21 and described in Table 13.

Figure 21. I2C Data Transmit Register (ICDXR)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 13. I2C Data Transmit Register (ICDXR) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
7-0	D	0-FFh	Transmit data.

3.9 I2C Mode Register (ICMDR)

The I2C mode register (ICMDR) contains the control bits of the I2C.

The I2C mode register (ICMDR) is shown in shown in Figure 22 and described in Table 14.

Figure 22. I2C Mode Register (ICMDR)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Reserved															
R-0															

15	14	13	12	11	10	9	8
NACKMOD	FREE	STT	Reserved	STP	MST	TRX	XA
R/W-0	R/W-0	R/W-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0

7	6	5	4	3	2	1	0
RM	DLB	IRS	STB	FDF	BC		
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0		

LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 14. I2C Mode Register (ICMDR) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
15	NACKMOD		No-acknowledge (NACK) mode bit (only applicable when the I2C is a receiver).
		0	In slave-receiver mode: The I2C sends an acknowledge (ACK) bit to the transmitter during the each acknowledge cycle on the bus. The I2C only sends a no-acknowledge (NACK) bit if you set the NACKMOD bit. In master-receiver mode: The I2C sends an ACK bit during each acknowledge cycle until the internal data counter counts down to 0. When the counter reaches 0, the I2C sends a NACK bit to the transmitter. To have a NACK bit sent earlier, you must set the NACKMOD bit.
		1	In either slave-receiver or master-receiver mode: The I2C sends a NACK bit to the transmitter during the next acknowledge cycle on the bus. Once the NACK bit has been sent, NACKMOD is cleared. To send a NACK bit in the next acknowledge cycle, you must set NACKMOD before the rising edge of the last data bit.
14	FREE		This emulation mode bit is used to determine the state of the I2C when a breakpoint is encountered in the high-level language debugger.
		0	When I2C is master: If SCL is low when the breakpoint occurs, the I2C stops immediately and keeps driving SCL low, whether the I2C is the transmitter or the receiver. If SCL is high, the I2C waits until SCL becomes low and then stops. When I2C is slave: A breakpoint forces the I2C to stop when the current transmission/reception is complete.
		1	The I2C runs free; that is, it continues to operate when a breakpoint occurs.
13	STT		START condition bit (only applicable when the I2C is a master). The RM, STT, and STP bits determine when the I2C starts and stops data transmissions (see Table 15). Note that the STT and STP bits can be used to terminate the repeat mode.
		0	In master mode, STT is automatically cleared after the START condition has been generated. In slave mode, if STT is 0, the I2C does not monitor the bus for commands from a master. As a result, the I2C performs no data transfers.
		1	In master mode, setting STT to 1 causes the I2C to generate a START condition on the I2C-bus. In slave mode, if STT is 1, the I2C monitors the bus and transmits/receives data in response to commands from a master.
12	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.

Table 14. I2C Mode Register (ICMDR) Field Descriptions (continued)

Bit	Field	Value	Description
11	STP		STOP condition bit (only applicable when the I2C is a master). The RM, STT, and STP bits determine when the I2C starts and stops data transmissions (see Table 15). Note that the STT and STP bits can be used to terminate the repeat mode.
		0	STP is automatically cleared after the STOP condition has been generated.
		1	STP has been set to generate a STOP condition when the internal data counter of the I2C counts down to 0.
10	MST		Master mode bit. MST determines whether the I2C is in the slave mode or the master mode. MST is automatically changed from 1 to 0 when the I2C master generates a STOP condition. See Table 16.
		0	Slave mode. The I2C is a slave and receives the serial clock from the master.
		1	Master mode. The I2C is a master and generates the serial clock on the SCL pin.
9	TRX		Transmitter mode bit. When relevant, TRX selects whether the I2C is in the transmitter mode or the receiver mode. Table 16 summarizes when TRX is used and when it is a don't care.
		0	Receiver mode. The I2C is a receiver and receives data on the SDA pin.
		1	Transmitter mode. The I2C is a transmitter and transmits data on the SDA pin.
8	XA		Expanded address enable bit.
		0	7-bit addressing mode (normal address mode). The I2C transmits 7-bit slave addresses (from bits 6-0 of ICSAR), and its own slave address has 7 bits (bits 6-0 of ICOAR).
		1	10-bit addressing mode (expanded address mode). The I2C transmits 10-bit slave addresses (from bits 9-0 of ICSAR), and its own slave address has 10 bits (bits 9-0 of ICOAR).
7	RM		Repeat mode bit (only applicable when the I2C is a master-transmitter). The RM, STT, and STP bits determine when the I2C starts and stops data transmissions (see Table 15). If the I2C is configured in slave mode, the RM bit is don't care.
		0	Nonrepeat mode. The value in the data count register (ICCNT) determines how many data words are received/transmitted by the I2C.
		1	Repeat mode. Data words are continuously received/transmitted by the I2C until the STP bit is manually set to 1, regardless of the value in ICCNT.
6	DLB		Digital loopback mode bit (only applicable when the I2C is a master-transmitter). This bit disables or enables the digital loopback mode of the I2C. The effects of this bit are shown in Figure 23. Note that DLB mode in the free data format mode (DLB = 1 and FDF = 1) is not supported.
		0	Digital loopback mode is disabled.
		1	Digital loopback mode is enabled. In this mode, the MST bit must be set to 1 and data transmitted out of ICDXR is received in ICDRR after n clock cycles by an internal path, where: n = ((I2C input clock frequency/prescaled module clock frequency) ɔ8) The transmit clock is also the receive clock. The address transmitted on the SDA pin is the address in ICOAR.
5	IRS		I2C reset bit. Note that if IRS is reset during a transfer, it can cause the I2C bus to hang (SDA and SCL are in a high-impedance state).
		0	The I2C is in reset/disabled. When this bit is cleared to 0, all status bits (in ICSTR) are set to their default values.
		1	The I2C is enabled.
4	STB		START byte mode bit (only applicable when the I2C is a master). As described in version 2.1 of the Philips I2C-bus specification, the START byte can be used to help a slave that needs extra time to detect a START condition. When the I2C is a slave, the I2C ignores a START byte from a master, regardless of the value of the STB bit.
		0	The I2C is not in the START byte mode.
		1	The I2C is in the START byte mode. When you set the START condition bit (STT), the I2C begins the transfer with more than just a START condition. Specifically, it generates: 1. A START condition 2. A START byte (0000 0001b) 3. A dummy acknowledge clock pulse 4. A repeated START condition The I2C sends the slave address that is in ICSAR.

Table 14. I2C Mode Register (ICMDR) Field Descriptions (continued)

Bit	Field	Value	Description
3	FDF		Free data format mode bit. Note that DLB mode in the free data format mode (DLB = 1 and FDF = 1) is not supported. See Table 16.
		0	Free data format mode is disabled. Transfers use the 7-/10-bit addressing format selected by the XA bit.
		1	Free data format mode is enabled.
2-0	BC	0-7h	Bit count bits. BC defines the number of bits (1 to 8) in the next data word that is to be received or transmitted by the I2C. The number of bits selected with BC must match the data size of the other device. Note that when BC = 0, a data word has 8 bits. If the bit count is less than 8, receive data is right aligned in the D bits of ICDRR and the remaining D bits are undefined. Also, transmit data written to ICDXR must be right aligned.
		0	8 bits per data word
		1h	1 bit per data word
		2h	2 bits per data word
		3h	3 bits per data word
		4h	4 bits per data word
		5h	5 bits per data word
		6h	6 bits per data word
		7h	7 bits per data word

Table 15. Master-Transmitter/Receiver Bus Activity Defined by RM, STT, and STP Bits

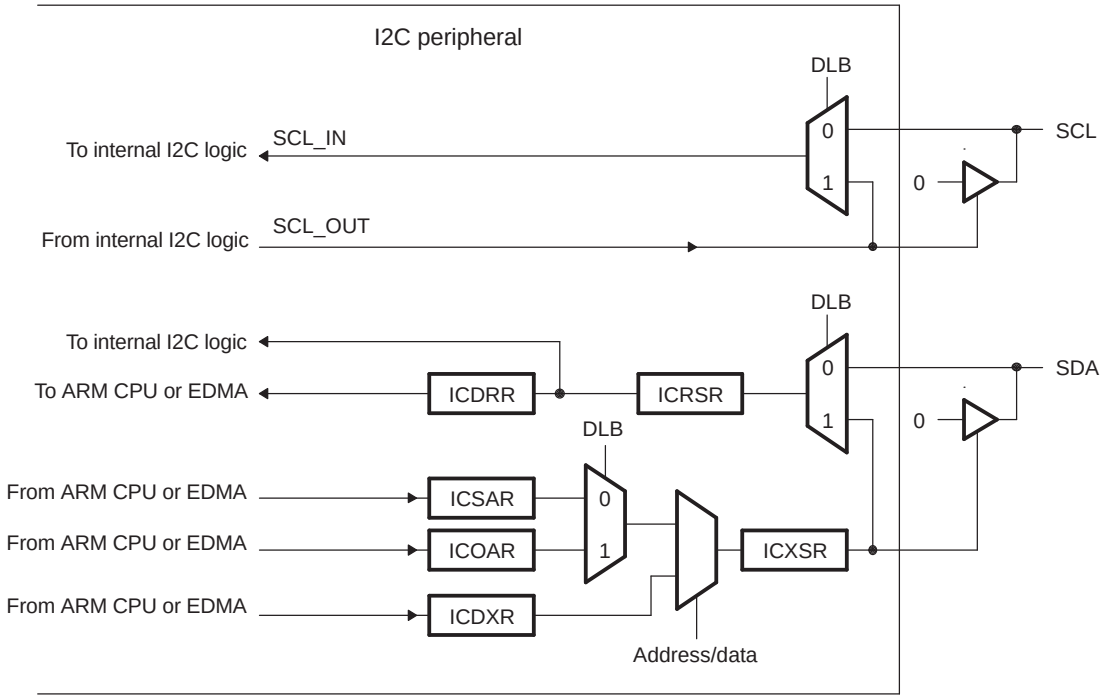
ICMDR Bit				
RM	STT	STP	Bus Activity(1)	Description
0	0	0	None	No activity
0	0	1	P	STOP condition
0	1	0	S-A-D..(*n*)..D	START condition, slave address, *n* data words (*n* = value in ICCNT)
0	1	1	S-A-D..(*n*)..D-P	START condition, slave address, *n* data words, STOP condition (*n* = value in ICCNT)
1	0	0	None	No activity
1	0	1	P	STOP condition
1	1	0	S-A-D-D-D..	Repeat mode transfer: START condition, slave address, continuous data transfers until STOP condition or next START condition
1	1	1	None	Reserved bit combination (No activity

(1) A = Address; D = Data word; P = STOP condition; S = START condition

Table 16. How the MST and FDF Bits Affect the Role of TRX Bit

ICMDR Bit			
MST	FDF	I2C State	Function of TRX Bit
0	0	In slave mode but not free data format mode	TRX is a don't care. Depending on the command from the master, the I2C responds as a receiver or a transmitter.
0	1	In slave mode and free data format mode	The free data format mode requires that the transmitter and receiver be fixed. TRX identifies the role of the I2C: TRX = 0: The I2C is a receiver. TRX = 1: The I2C is a transmitter.
1	0	In master mode but not free data format mode	TRX identifies the role of the I2C: TRX = 0: The I2C is a receiver. TRX = 1: The I2C is a transmitter.
1	1	In master mode and free data format mode	The free data format mode requires that the transmitter and receiver be fixed. TRX identifies the role of the I2C: TRX = 0: The I2C is a receiver. TRX = 1: The I2C is a transmitter.

Figure 23. Block Diagram Showing the Effects of the Digital Loopback Mode (DLB) Bit



3.10 I2C Interrupt Vector Register (ICIVR)

The I2C interrupt vector register (ICIVR) is used by the CPU to determine which event generated the I2C interrupt. Reading ICIVR clears the interrupt flag; if other interrupts are pending, a new interrupt is generated. If there are more than one interrupt flag, reading ICIVR clears the highest priority interrupt flag. Note that you must read (clear) ICIVR before doing another start; otherwise, ICIVR could contain an incorrect (old interrupt flags) value.

The I2C interrupt vector register (ICIVR) is shown in Figure 24 and described in Table 17.

Figure 24. I2C Interrupt Vector Register (ICIVR)

31	16
Reserved	
R-0	

15	2	0
Reserved	INTCODE	
R-0	R-0	

LEGEND: R= Read only; -*n* = value after reset

Table 17. I2C Interrupt Vector Register (ICIVR) Field Descriptions

Bit	Field	Value	Description
31-3	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
2-0	INTCODE	0-7h	Interrupt code bits. The binary code in INTCODE indicates which event generated an I2C interrupt.
		0	None
		1h	Arbitration-lost interrupt (AL)
		2h	No-acknowledgment interrupt (NACK)
		3h	Register-access-ready interrupt (ARDY)
		4h	Receive-data-ready interrupt (ICRRDY)
		5h	Transmit-data-ready interrupt (ICXRDY)
		6h	Stop condition detected interrupt (SCD)
		7h	Address-as-slave interrupt (AAS)

3.11 I2C Extended Mode Register (ICEMDR)

The I2C extended mode register (ICEMDR) is used to indicate which condition generates a transmit data ready interrupt.

The I2C extended mode register (ICEMDR) is shown in Figure 25 and described in Table 18.

Figure 25. I2C Extended Mode Register (ICEMDR)

31	16
Reserved	
R-0	

15	1	0
Reserved		BCM
R-0		R/W-1

LEGEND: R/W = Read/Write; R= Read only; -*n* = value after reset

Table 18. I2C Extended Mode Register (ICEMDR) Field Descriptions

Bit	Field	Value	Description
31-1	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
0	BCM		Backward compatibility mode bit. Determines which condition generates a transmit data ready interrupt. The BCM bit only has an effect when the I2C is operating as a slave-transmitter.
		0	The transmit data ready interrupt is generated when the master requests more data by sending an acknowledge signal after the transmission of the last data.
		1	The transmit data ready interrupt is generated when the data in ICDXR is copied to ICXSR.

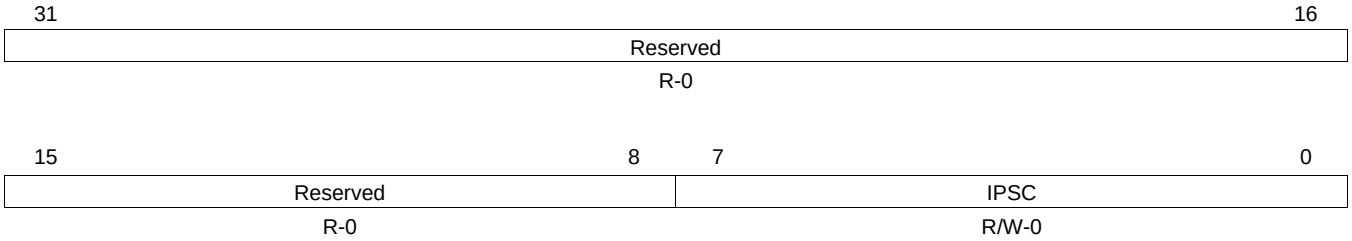
3.12 I2C Prescaler Register (ICPSC)

The I2C prescaler register (ICPSC) is used for dividing down the I2C input clock to obtain the desired prescaled module clock for the operation of the I2C.

The IPSC bits must be initialized while the I2C is in reset (IRS = 0 in ICMDR). The prescaled frequency takes effect only when the IRS bit is changed to 1. Changing the IPSC value while IRS = 1 has no effect.

The I2C prescaler register (ICPSC) is shown in Figure 26 and described in Table 19.

Figure 26. I2C Prescaler Register (ICPSC)



LEGEND: R/W = Read/Write; R = Read only; -*n* = value after reset

Table 19. I2C Prescaler Register (ICPSC) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
7-0	IPSC	0-FFh	I2C prescaler divide-down value. IPSC determines how much the I2C input clock is divided to create the I2C prescaled module clock: I2C clock frequency = I2C input clock frequency/(IPSC + 1) **Note:** IPSC must be initialized while the I2C is in reset (IRS = 0 in ICMDR).

3.13 I2C Peripheral Identification Register (ICPID1)

The I2C peripheral identification registers (ICPID1) contain identification data (class, revision, and type) for the peripheral.

The I2C peripheral identification register (ICPID1) is shown in Figure 27 and described in Table 20.

Figure 27. I2C Peripheral Identification Register 1 (ICPID1)

31	16
Reserved	
R-0	

15	8	7	0
Class		Revision	
R-01h		R-05h	

LEGEND: R = Read only; -*n* = value after reset

Table 20. I2C Peripheral Identification Register 1 (ICPID1) Field Descriptions

Bit	Field	Value	Description
31-16	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
15-8	Class		Identifies class of peripheral.
		1h	Serial port
7-0	Revision		Identifies revision of peripheral.
		05h	Current revision of peripheral.

3.14 I2C Peripheral Identification Register (ICPID2)

The I2C peripheral identification register (ICPID2) is shown in Figure 28 and described in Table 21.

Figure 28. I2C Peripheral Identification Register 2 (ICPID2)

31	16
Reserved	
R-0	

15	8	7	0
Reserved		TYPE	
R-0		R-05h	

LEGEND: R = Read only; -*n* = value after reset

Table 21. I2C Peripheral Identification Register 2 (ICPID2) Field Descriptions

Bit	Field	Value	Description
31-8	Reserved	0	These reserved bit locations are always read as zeros. A value written to this field has no effect.
7-0	TYPE		Identifies type of peripheral.
		05h	I2C

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