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Renesas Technology Corp.
Customer Support Dept.
April 1, 2003

M16C Family

Concept of the Power Control

1.0 Abstract

This application notes explains about low-power operations using Wait Mode and Stop Mode.

2.0 Introduction

The explanation of this issue is applied to the following condition:

Applicable MCU: M16C Family

3.0 Contents

3.1 Outline

In portable systems such as mobile phones or PDAs, the key issues are reducing power consumption and extending the life of the battery. The M16C Family offers a unique chip architecture and superior internal layout/wiring, resulting in greatly reduced MCU power consumption. Effective use of the internal peripheral functions and MCU modes is the key to fully benefiting from these advanced power-saving features.
We provided the following application examples for all users to fully understand the advanced low-power consumption operations of the M16C Family and how to apply these features in their systems.

3.2 Power Saving Using Operation Modes

MCU consumption current decreases in the following order:

Normal Operation Mode **>** Wait Mode **>** Stop Mode

1. Normal Operation Mode
   The MCU operates with a system clock BCLK, generated by either the main clock or sub-clock. The internal peripherals operate with individually configured clocks.

2. Wait Mode
   The CPU stops its operation in this mode but oscillators are not affected.
   This mode is initiated by the WAIT instruction and the MCU returns to the normal operation mode upon receipt of an interrupt request or hardware reset.

3. Stop Mode
   All oscillators stop in this mode. As a result, not only the CPU but also all internal peripherals stop operating.
   This stop mode is initiated by setting the all clock stop control bit to "1". The MCU returns to the normal operation mode upon receiving an interrupt request or a hardware reset.

3.3 Power Saving By Peripheral Functions

Programmable I/O Port

When the MCU is initiated in the wait or stop mode, the programmable I/O ports will hold their prior states. If the output port is set for an active state, a current will flow through the port. If the input port is applied with the intermediate voltage or is left the floating state, a penetration current may flow to the port.

To prevent the current flow:

For an output port, output a level that current does not flow, creating an in-active condition. For an input port, pull-up the pin externally to fix the level. For more details, refer to Chapter 3.5 CMOS Logic Circuit for constructing Programmable I/O Port.

External Address Bus/External Data Bus

Ports P0 to P5 become the address bus, data bus, and control signal I/O pins in the memory expansion and microprocessor modes. The bus holds its state from the last access just before the MCU is switched to the wait or stop mode. This means that, depending on state of the bus, current may flow to the pins.

To prevent the current flow, after setting the MCU to the single-chip mode, which sets the pins used as the bus to programmable I/O ports, set the ports to the state that current does not flow. For more details, refer to Chapter 3.6 Power Saving in Memory Expansion and Microprocessor Modes.

A-D Converter

Current flows to the VREF pin constantly. To prevent the current flow, set the Vref connection bit to "0".

D-A Converter

The D-A converter also holds its prior state when the MCU moves to the wait/stop mode. Disable the D-A output (D-A output enable bit = "0"), which sets the D-A output pin to a programmable I/O port. In addition, the value set to the D-A register must be one that current does not flow.

Other Internal Peripherals

You can also reduce power consumption by setting output pins of other internal peripherals to an in-active condition. If the level of an output pin of an internal peripheral cannot be controlled, disable the peripheral, which sets the pin to a programmable I/O port. Then output a level that current does not flow, creating an in-active condition.

The level of the input pins of the internal peripherals must be fixed externally.

External Clock

When using an external clock as the main clock, set the main clock stop bit to "1". This will stop operation of the XOUT pin and therefore reduce the consumption current. (When using an external clock, note that the clock is always input regardless of the state of the main clock stop bit.)

3.4 Confirming Your Power Savings

To maintain an effective power saving condition in the wait/stop mode, please check the following items and hold the respective pins stable.

Pins in use..

Input ports:

Confirm that the input port is inputting a stable output from the peripheral device (IC, etc.). If the power from the peripheral device is shut down and the input voltage of the port becomes unstable, that causes a penetration current to flow through the port.

Output ports:

Make sure the output port is outputting an identical level with the peripheral device and is not outputting "H" while the power from the peripheral device is shut down. If the port outputs a different level from the device or outputs "H" to the device that is turned off, that causes a current to flow through the port.

Unused pins..

Connect unused pin to Vss through a resistor and set the pin to input, or leave the pin open and set the pin to output an "L" level.

How to confirm pin states (recommended methods)

(1) Is the input port inputting a fixed voltage level? Is the output port outputting a fixed voltage level?

Check each port using a measurement device.

(2) Is the port or peripheral device outputting a proper "L" level?

Pull up the pin and measure the pin level. If you can measure "L" level in this condition, the pin is outputting a proper "L" level.

(3) Is the port or peripheral device outputting a proper "H" level?

Pull down the pin and measure the pin level. If you can measure "H" level in this condition, the pin is outputting a proper "H" level.

3.5 CMOS Logic Circuit for constructing Programmable I/O Port

The programmable I/O port of the M16C Family adopts a CMOS logic architecture consisting of two switch elements, PMOS and NMOS elements (see Fig. 3.5.1).

Normally, when either the PMOS or NMOS switch is ON, the other element (i.e. NMOS or PMOS, respectively) is OFF, which prevents the flow of a penetration current. However, when the intermediate voltage level is input to the port, it causes both the PMOS and NMOS switches to be set to ON (see Fig. 3.5.2).

In this situation, a current flows through the PMOS and NMOS elements, which we call the penetration current.

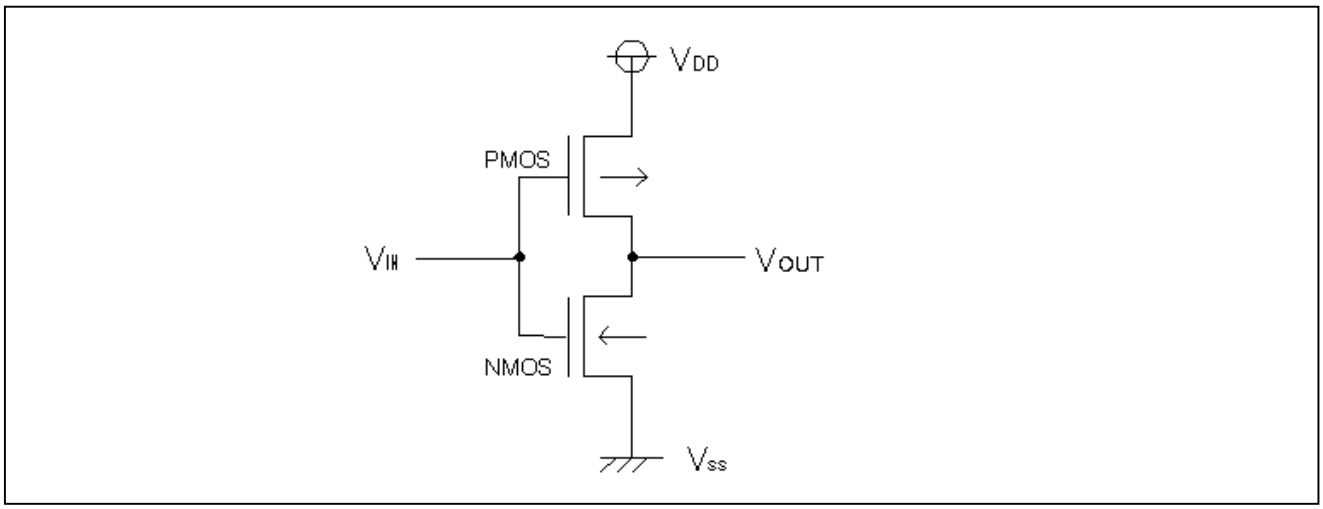

Figure3.5.1 CMOS Logic

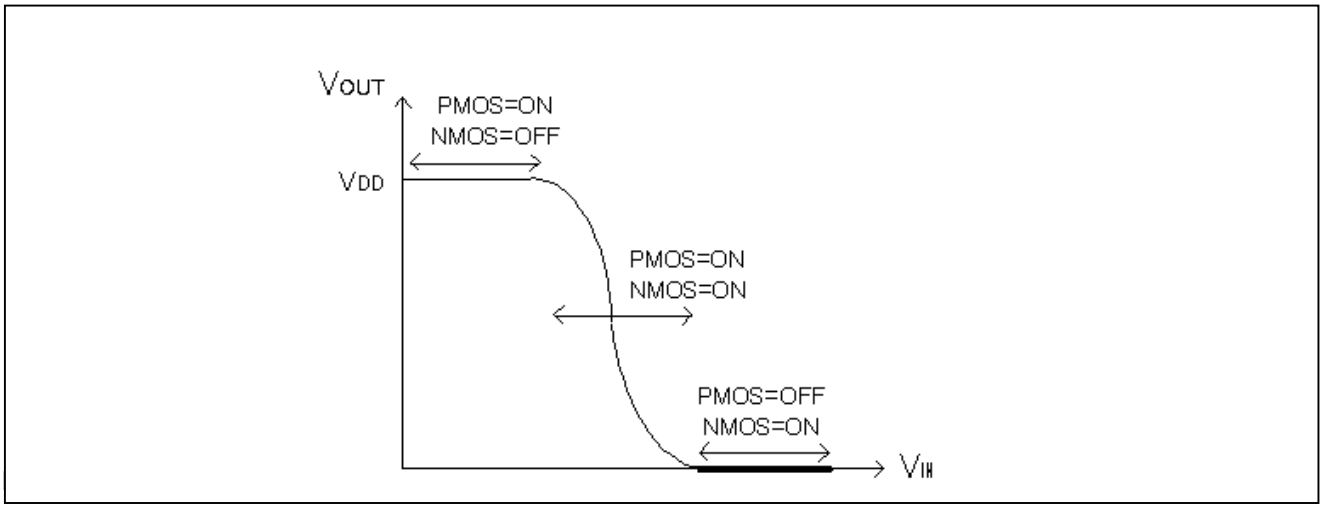

Figure3.5.2 PMOS-NMOS Operations

3.6 Power Saving in the Memory Expansion and Microprocessor Modes

The bus holds its state from the last access even after the MCU is switched to the wait or stop mode, making it difficult to set a certain voltage level to the pins when you set the MCU to the wait or stop mode.
On the other hand, once the processor mode is switched to the single-chip mode, the pins used as the bus will become programmable I/O ports, enabling you to easily set any voltage level to the pins by software.

Procedure

1. Set the processor mode of the MCU to the single-chip mode.
2. Set each programmable I/O port, previously used as the bus, to hold a fixed voltage level, with software.
3. Set the MCU to the wait or stop mode.

Note 1: In the memory expansion mode, place the above-mentioned program in the internal ROM. In the microprocessor mode, transfer the program to an internal RAM area and execute it there.

Note 2: Perform Step 2 for the programmable I/O ports only after switching to the single-chip mode.

Setup Example: M16C/60 Series

The following is an example program for setting the MCU to the wait or stop mode in the memory expansion mode.

```
/*----- PROCESSER MODE SET -----*/
PRCR.bit.PRC1 = TRUE;       /* Enable writing to processor mode registers 0 and 1 */
PM0.all = 0;                /* Memory expansion mode --> Single-chip mode */
PRCR.bit.PRC1 = FALSE;      /* Disable writing to processor mode registers 0 and 1
*/

/*----- PORT DATA SET -----*/
P0.all = DT_STOP_P0;        /* Port data control in low power consumption mode */
P1.all = DT_STOP_P1;        /* Port data control in low power consumption mode */
P2.all = DT_STOP_P2;        /* Port data control in low power consumption mode */
P3.all = DT_STOP_P3;        /* Port data control in low power consumption mode */
P4.all = DT_STOP_P4;        /* Port data control in low power consumption mode */
P5.all = DT_STOP_P5;        /* Port data control in low power consumption mode */
P6.all = DT_STOP_P6;        /* Port data control in low power consumption mode */
P7.all = DT_STOP_P7;        /* Port data control in low power consumption mode */
P8.all = DT_STOP_P8;        /* Port data control in low power consumption mode */
P9.all = DT_STOP_P9;        /* Port data control in low power consumption mode */
P10.all = DT_STOP_P10;      /* Port data control in low power consumption mode */

/*----- PORT DIRCTION SET -----*/
PD0.all = DIR_STOP_P0; /* Port direction control in low power consumption mode */
PD1.all = DIR_STOP_P1; /* Port direction control in low power consumption mode */
PD2.all = DIR_STOP_P2; /* Port direction control in low power consumption mode */
PD3.all = DIR_STOP_P3; /* Port direction control in low power consumption mode */
PD4.all = DIR_STOP_P4; /* Port direction control in low power consumption mode */
PD5.all = DIR_STOP_P5; /* Port direction control in low power consumption mode */
PD6.all = DIR_STOP_P6; /* Port direction control in low power consumption mode */
PD7.all = DIR_STOP_P7; /* Port direction control in low power consumption mode */
PD8.all = DIR_STOP_P8; /* Port direction control in low power consumption mode */
PRCR.bit.PRC2 = TRUE;  /* Enable writing to port P9 direction register */
PD9.all = DIR_STOP_P9; /* Port direction control in low power consumption mode */
PD10.all = DIR_STOP_P10; /* Port direction control in low power consumption mode */

/*----- DA SET -----*/
DACON.bit.DA0E = FALSE;     /* Disable D-A output */
DACON.bit.DA1E = FALSE;     /* Disable D-A output */
DA0 = 0;                    /* DA0 0 [V]
DA1 = 0;                    /* DA0 0 [V]
```

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