R32C/100 Series

Three-phase Motor Control Timers
(Triangular Wave Modulation Mode, Three-phase Mode 1)

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1. Abstract

The R32C/100 Series allows users to select the three-phase motor control timer function operation mode, depending on the user system.
This application note describes microcomputers (MCUs) operation when the marked functions in Table 1.1 are selected.

Table 1.1 Settings

Item	Setting	
Modulation mode		Sawtooth wave modulation mode
	✓	Triangular wave modulation mode
Timers A11, A21, and A41 control (three-phase mode)		Timers A11, A21, and A41 not used (three-phase mode 0).
	✓	Timers A11, A21, and A41 used (three-phase mode 1).
Active level	✓	Active low
		Active high
Three-phase output pins	✓	Pins U, $\overline{U}$, V, $\overline{V}$, W, and $\overline{W}$ of ports P7 and P8 used.
		Pins U, $\overline{U}$, V, $\overline{V}$, W, and $\overline{W}$ of port P3 used.

2. Introduction

The application example described in this document applies to the following MCUs:

- MCUs: R32C/116 Group, R32C/117 Group, and R32C/118 Group

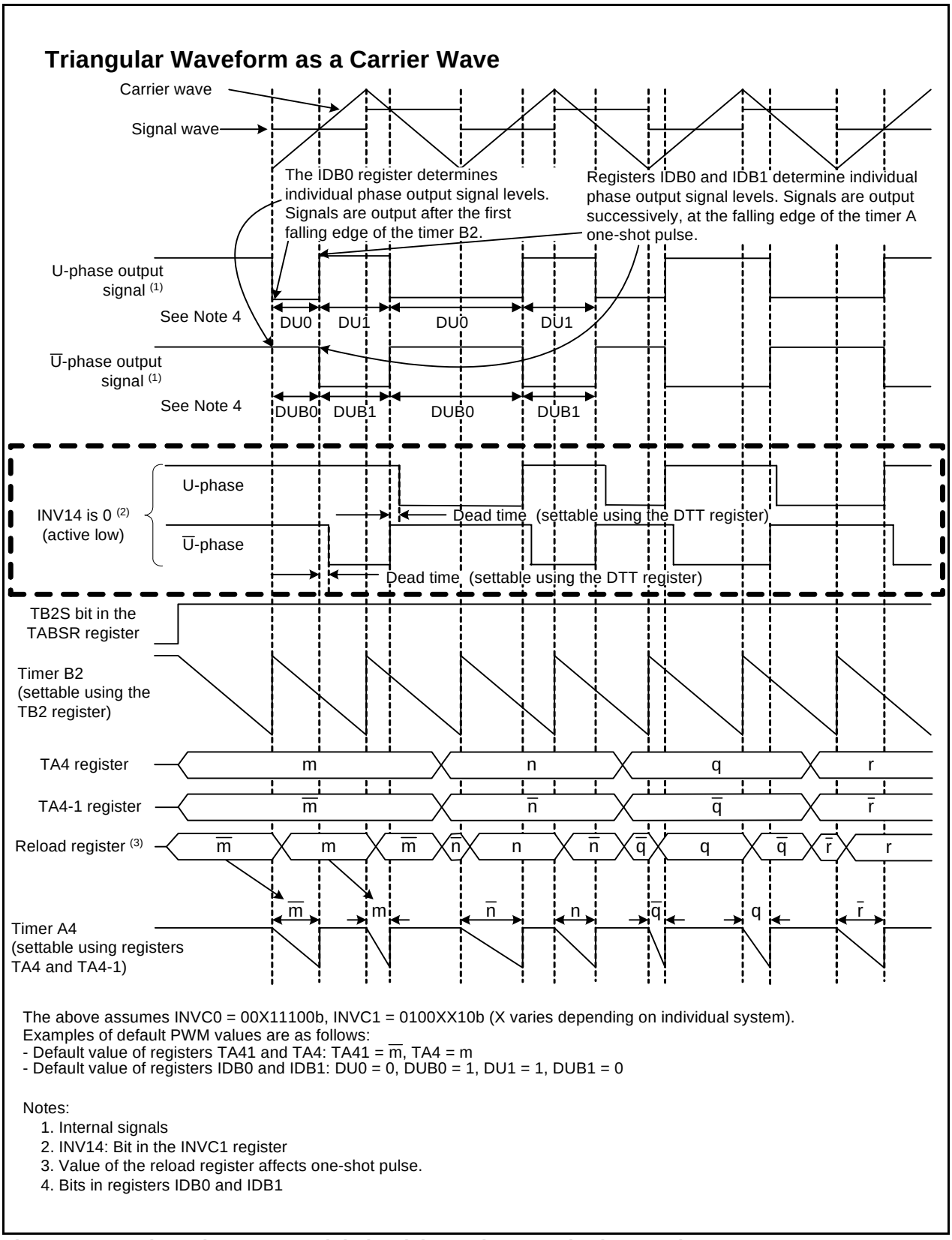
This application note can be used with other R32C/100 Series MCUs which have the same special function registers (SFRs) as the above groups. Check the user's manual for any modifications to functions. Careful evaluation is recommended before using the program described in this application note.

3. Detailed Description

3.1 Triangular Wave Modulation Mode and Three-phase Mode 1

(1) Set INV02 bit in the INVC0 register to 1 (three-phase motor control timer function), the INV06 bit to 0 (triangular wave modulation mode), and the INV11 bit in the INVC1 register to 1 (three-phase mode 1).
(2) Set bits TAiS, and TB2S in the TABSR register to 1 (start counter) to decrement the timer B2 counter value (i = 4, 1, and 2).
(3) The TAi1 and TAi register setting values are alternately transferred to the reload register because of three-phase mode 1 set.
(4) A one-shot pulse is output from the timer Ai when the timer B2 counter underflows.
(5) Each phase is output at the timing of the timer Ai one-shot pulse falling edge.

Figure 3.1 shows an example diagram of the triangular wave modulation (three-phase mode 1).



The above assumes INVC0 = 00X11100b, INVC1 = 0100XX10b (X varies depending on individual system).
Examples of default PWM values are as follows:
- Default value of registers TA41 and TA4: TA41 = $\overline{m}$, TA4 = m
- Default value of registers IDB0 and IDB1: DU0 = 0, DUB0 = 1, DU1 = 1, DUB1 = 0

Notes:
1. Internal signals
2. INV14: Bit in the INVC1 register
3. Value of the reload register affects one-shot pulse.
4. Bits in registers IDB0 and IDB1

Figure 3.1 Triangular Wave Modulation (Three-phase Mode 1) Operation

3.2 Dead Time

The signal to switch between active low and active high has a dead time. Set the INV14 bit in the INVC1 register to select active low or active high.
Figure 3.2 shows the dead time when active low logic is selected.

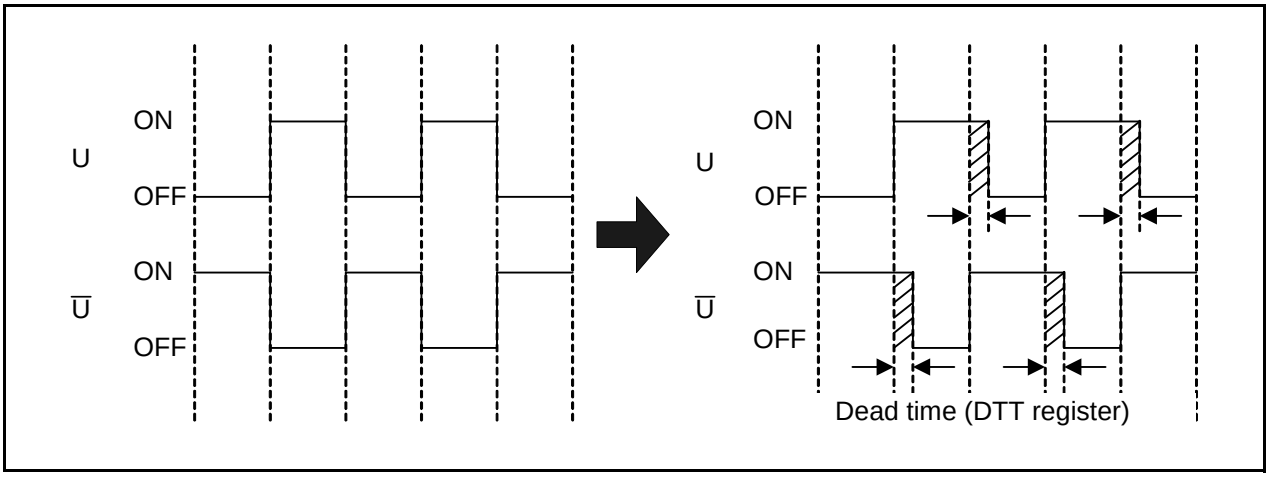
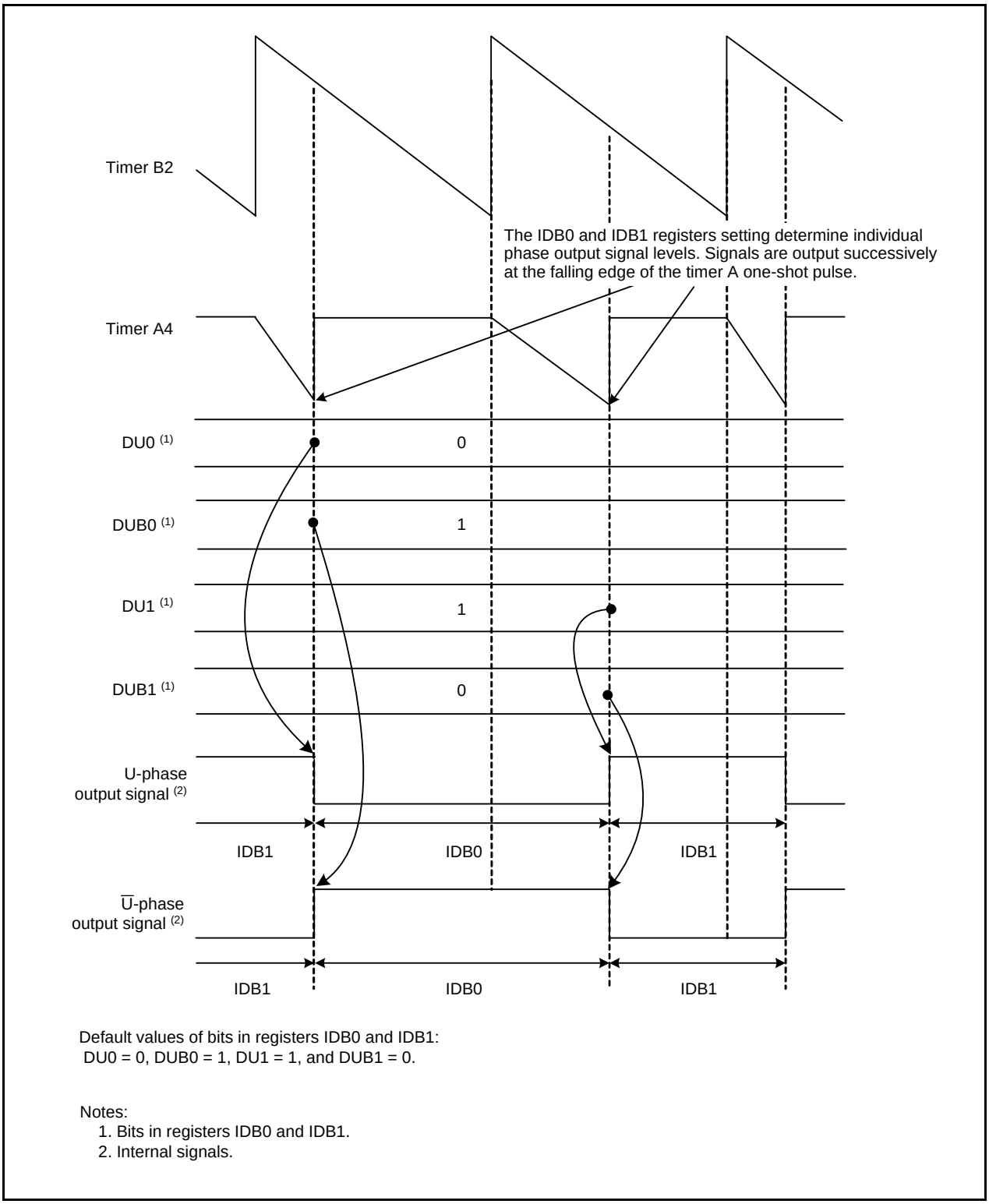


Figure 3.2 Dead Time (Active Low)

3.3 Three-phase Output Buffer Register (IDB0 and IDB1 Registers)

Figure 3.3 shows a U-phase output signal operation example with registers IDB0 and IDB1 and each phase output signal.
When the triangular wave modulation mode is selected, the individual phase output port reflects the IDB1 register setting as soon as the timer starts.



Default values of bits in registers IDB0 and IDB1:
DU0 = 0, DUB0 = 1, DU1 = 1, and DUB1 = 0.

Notes:
1. Bits in registers IDB0 and IDB1.
2. Internal signals.

Figure 3.3 U-Phase Output Signal Operation Example

3.4 Setting

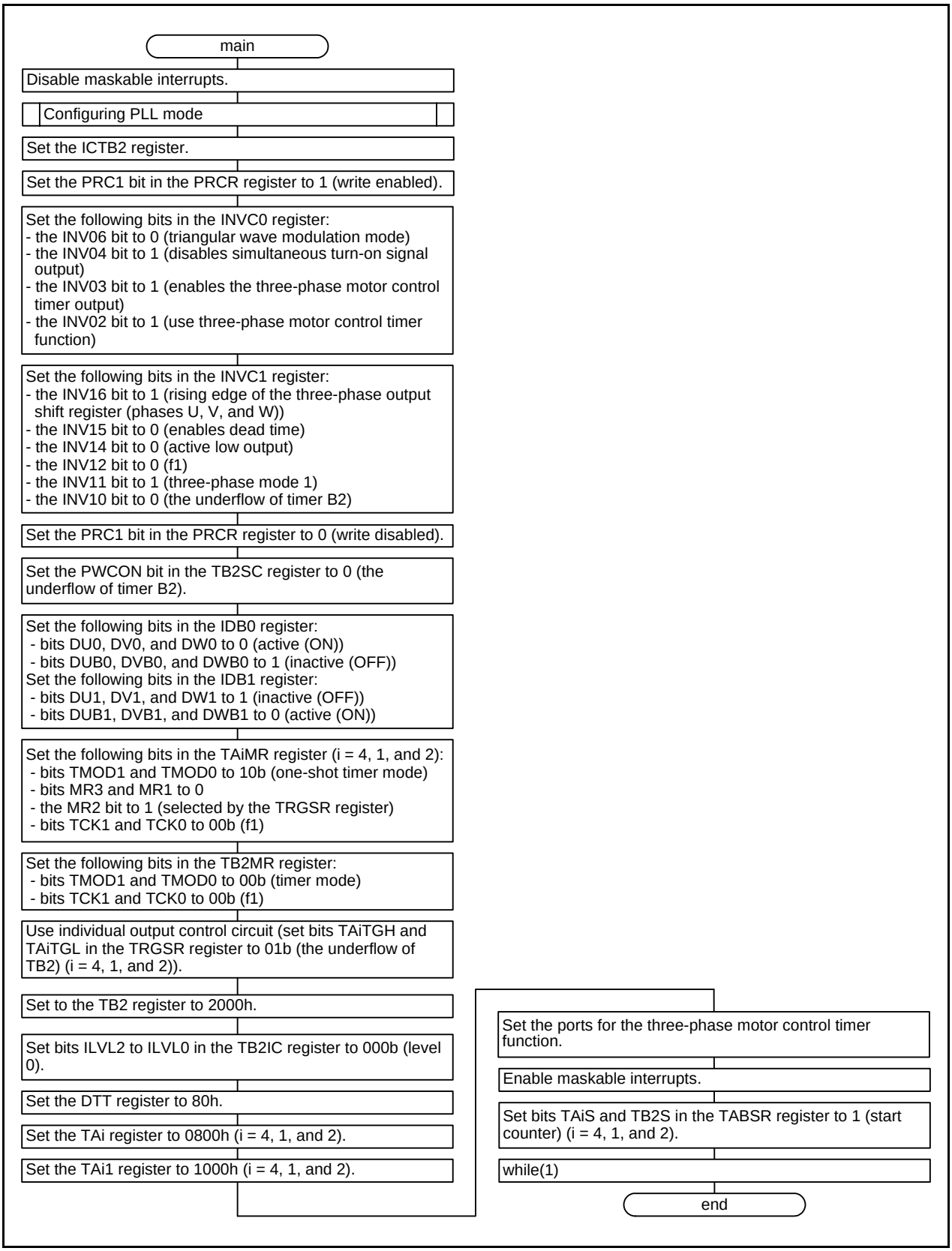


Figure 3.4 Triangular Wave Modulation (Three-phase Mode 1) Flowchart

3.5 Notes for Registers TAi and TAi1 Settings (i = 4, 1, and 2)

Note the following information when setting registers TAi and TAi1.

(1) TAi register setting

Users must avoid setting the TAi register as follow except if necessary.
If the TAi register is set to 0000h (0000h or 0001h when the INV12 bit in the INVC1 register to 1 (f1 divided-by-2)), the TAi timer counter will not start.
Besides, if the TAi register is set to a value larger than the TB2 register setting value (a value larger than "TB2 register setting value - 1" when the INV12 bit in the INVC1 register to 1 (f1 divided-by-2)), the TAi timer counter continues running the number of cycles determined by the TB2 register.
At the end of both events, the output signal level does not change since no falling edges occur.

(2) Dead time timer restart

Even if the TAi register setting causes the dead time timer to restart while a dead time timer is counting, the dead time timer does not restart counting.

If the following conditions are met, the dead time timer will not restart counting:

Triangular wave modulation mode (three-phase mode 0): f1 selected as count source for the dead time timer
((TB2 register setting value + 1) - TAi register setting value at an even number of times) + TAi register setting value at an odd number of times < setting value of dead time timer
TAi register setting value at an even number of times + ((TB2 register setting value + 1) - TAi register setting value at an odd number of times) < setting value of dead time timer

Triangular wave modulation mode (three-phase mode 1): f1 selected as count source for the dead time timer
((TB2 register setting value + 1) - TAi1 register setting value) + TAi register setting value < setting value of dead time timer
TAi1 register setting value + ((TB2 register setting value + 1) - TAi register setting value) < setting value of dead time timer

Sawtooth wave modulation mode: f1 selected as count source for the dead time timer
((TB2 register setting value + 1) - TAi register setting value) - 1 < setting value of dead time timer
TAi register setting value - 1 < setting value of dead time timer

4. Sample Program

A sample program can be downloaded from the Renesas Electronics website.

5. Reference Documents

R32C/116 Group User's Manual: Hardware Rev.1.10
R32C/117 Group User's Manual: Hardware Rev.1.10
R32C/118 Group User's Manual: Hardware Rev.1.10
The latest versions can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Electronics website.

C Compiler Manual
R32C/100 Series C Compiler Package V.1.02 C Compiler User's Manual Rev.2.00
The latest version can be downloaded from the Renesas Electronics website.

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Revision History	R32C/100 Series Three-phase Motor Control Timers (Triangular Wave Modulation Mode, Three-phase Mode 1)

Rev.	Date	Description	
		Page	Summary
1.00	Oct. 29, 2010	—	First edition issued

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The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins

   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.

   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.

   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products

   Before changing from one product to another, i.e. to one with a different part number, confirm that the change will not lead to problems.

   — The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

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