Course Introduction

- **Purpose**
  This course provides an introduction to the peripheral functions built into R8C Tiny series microcontrollers (MCUs).

- **Objective**
  - Learn about the features and operation of the TimerRA, TimerRB, TimerRC, TimerRD and TimerRE functions.
  - Understand the basics of the **Watchdog Timer**.
  - Discover how the **Power-on Reset** (POR) and **Low-Voltage Detect** (LVD) functions operate.

- **Content**
  - 33 pages
  - 6 questions

- **Learning Time**
  - 35 minutes
### Versatile Set of Timers

<table>
<thead>
<tr>
<th>Feature</th>
<th>Timer RA</th>
<th>Timer RB</th>
<th>Timer RC</th>
<th>Timer RD</th>
<th>Timer RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer structure</td>
<td>8 bit</td>
<td>8-bit</td>
<td>16 bit</td>
<td>2 x 16 bit</td>
<td>4 bit + 8 bit</td>
</tr>
<tr>
<td>Prescaler</td>
<td>8 bit</td>
<td>8 bit</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Timer Mode</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Pulse Output Mode</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Event Counter Mode</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pulse Width Measurement Mode</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pulse Period Measurement Mode</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Programmable Waveform Generation Mode</td>
<td>-</td>
<td>Yes</td>
<td>Yes, 2 PWM modes</td>
<td>Yes, 4 PWM modes</td>
<td>-</td>
</tr>
<tr>
<td>Programmable One-Shot Generation Mode</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Programmable Wait One-Shot Generation Mode</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Input Capture Mode</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Output Compare Mode</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Real Time Clock Mode</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The **Watchdog Timer** is covered separately in this course.
Which of the following timers on the R8C family is 16bit?
Click “Submit” when you are finished.

- Timer RB
- Timer RC
- Timer RE
- Timer RA
Which of the following timers on the R8C family is 16bit?
Click “Done” when you are finished.

A  Timer RA
B  Timer RB
C  Timer RC
D  Timer RE
Timer RB

TCK1 to TCK0 bits
f1 = 00b
f3 = 01b
f2 = 10b

Timer RA underflow
f2 = 11b

TCKCUT bit

TCK to TCKCUT bits

Input polarity selected to be one edge or both edges

Polarity select

TOCNT = 0

TOCNT = 1

P3_1 bit in P3 register

TOPL = 1

TOPL = 0

Toggle flip-flop

TCSTF bit

TMOD1 to TMOD0 bits = 01b, 10b, 11b

INT0 pin

Digital filter

TMOD1 to TMOD0 bits = 01b, 10b, 11b

INT0PL bit

INT0EN bit

TSR, TCSTF: Bit in TRBCR register
TOSSTF: Bit in TRBOCR register
TOPL, TOCNR, INOSTG, INOSEG: Bits in TRBIOC register
TMOD1 to TMOD0, TCK1 to TCK0, TCKCUT: Bits in TRBMR register

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Timer RD

Channel i

TRDi register
TRDGRAI register
TRDGRBI register
TRDGRCi register
TRDGRI register
TRDDFI register
TRDCRI register
TRDIORAi register
TRDIORCi register
TRDSRI register
TRDIERi register
TRDPOCRi register
TRDSTR register
TRDMR register
TRDPMR register
TRDFCR register
TRDOER1 register
TRDOER2 register
TRDOCR register

Count source select circuit

f1, f2, f4, f8, f32, fOCO40M

INT0
TRDIOA0/TRDCLK
TRDIOB0
TRDIOC0
TRDIOD0
TRDIOA1
TRDIOB1
TRDIOC1
TRDIOD1

Channel 0 interrupt request
Channel 1 interrupt request
A/D trigger
Timer RE
Timer Mode

The timer counts an internally generated count source.

- **Operation:** When the timer underflows, it reloads the register contents before continuing to count.

**Timer RA Mode register**

<table>
<thead>
<tr>
<th>Register Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>08h</td>
</tr>
</tbody>
</table>

Timer RA Mode Register is used to put Timer RA into the Timer Mode and start/stop the counting.

**Example:** Timer RA

![Diagram of Timer RA circuit]

- **Count Source**
  - f1
  - f8
  - f1C0
  - f2

- **Count Start flag**

- **Reload register**
  - 1
  - 2

- **TRAPRE Pre-scaler**
  - 0

- **TRA Counter**
  - 2

- **Timer RA Interrupt**
The timer counts an internally generated count source, the TRAO pin outputs a pulse whose polarity is inverted when the timer underflows.

- **Operation:** When the timer underflows, it reloads the register contents before continuing to count.

**Example:** Timer RA

The diagram illustrates the Pulse Output Mode with components labeled as follows:

- **Count Source:** f1, f2, f8, fOCO
- **Count Start flag**
- **TRAPRE Pre-scaler** with contents 1
- **TRA Counter** with contents 2
- **Toggle flip-flop**
- **TRAO**

The timer counts using a pre-scaler and counter, and the TRAO pin outputs a pulse whose polarity is inverted.
Pulse Output Mode: Timer RA Example

The timer counts an internally generated count source, the TRAO pin outputs a pulse whose polarity is inverted when the timer underflows.

- **Operation:** When the timer underflows, it reloads the register contents before continuing to count.
Is the following statement true or false? Click “Submit” when you are finished.

“The functionality of the Pulse Output Mode is exactly the same as in Timer mode, except a pulse is output on the TRAO pin.”

- True
- False
Question

Is the following statement true or false? Click “Done” when you are finished.

“The functionality of the Pulse Output Mode is exactly the same as in Timer mode, except a pulse is output on the TRAO pin.”

True

False
Generate Complementary Outputs

TRAIO has the option to be a port pin or an inverted output of TRAO

**Example:** Timer RA

```
Count Source

f1
f8
fOCO
f2

1

TRAPRE Pre-scaler

1

2

TRA Counter

Reload register

Reload register

Count Start flag

CK

Toggle flip-flop

01

TRAIO

1

TRAIO has the option to be a port pin or an inverted output of TRAO

Example: Timer RA
```
Event Counter Mode

The timer counts an external signal fed to TRAIO pin.
- Operation: When the timer underflows, it reloads the register contents before continuing to count.

Example: Timer RA

Timer RA Mode Register is used to put Timer RA into Event Counter Mode, selecting the active edge of the count source, and starts/stops the counter.
Pulse Width Measurement Mode

The timer measures the pulse width of an external signal fed into the TRAIO pin.

**Example: Timer RA**

- **Count Source**
  - f1
  - f8
  - f32
  - f2

- **Count Start flag**

- **TRAIO pin**

- **IR bit in TRAIC register**

- **TUNDF bit in TRACR register**

- **Reset register**
  - 0
  - 5

- **TRAPRE Pre-scaler**
  - 0

- **TRA Counter**
  - 5

- **Timer RA Interrupt**

- **Count Stop**

- **Timer Underflow**
Pulse Period Measurement Mode: Timer RA

Underflow signal of prescaler

TRAIO pin

Period being measured

Timer RA reloads

Contents of read out buffer

0F 0E 0D

0B 0A 09

Timer RA reloads

0F 0E 0D

00 0F

Timer RA reloads

Timer RA active

Edge detected (TEGDF bit)

0F 0E 0D

0B 0A 09

00 0F

Timer RA read

Timer RA read

Contents being measured

Cleared to “0” by program

Timer RA underflow

(TUNDF bit)

Timer RA interrupt

Period being measured

0F 0E 0D

0B 0A 09

00 0F

Timer RA read

Timer RA read

Cleared to “0” by program
Programmable Waveform Gen. Mode

A signal is output from the TRBO pin which is inverted each time the counter underflows, it reloads the contents of primary reload register and secondary reload register alternately before continuing to count.

Example: Timer RB
Programmable One-Shot Gen. Mode

Example: Timer RB

Count Source

Count Start flag

Reload register

0

TRBPRE Pre-scaler

1

TRBPR register

Timer RB Counter

Digital Filter

Input polarity selected to be one edge or both edges

TSTART

POLARITY SELECT

TOSSTF

INT0PL

INT0EN

INT0

TMODx

CK

Toggle flip-flop

P3_2 bit

TRBO

TMOD bits
Match each timer mode to its function by dragging the letters on the left to their appropriate locations on the right. Click “Submit” when you are finished.

- **Event Counter Mode**
  
  If an underflow occurs while the timer is counting, the TUNDF bit goes high so that the underflow can be taken into account.

- **Pulse Width Measurement Mode**
  
  The input that the timer counts is an external signal that is fed into the MCU through the TRAIO pin.

- **Pulse Period Measurement Mode**
  
  When a trigger occurs, the timer starts operating once for a given period.

- **Programmable Waveform Generator Mode**
  
  A signal is output from the TRBO pin and is inverted each time the counter underflows.

- **Programmable One-Shot**
  
  After the Count Start bit has been set, the

**PROPERTIES**

- On passing, 'Finish' button: Goes to Next Slide
- On failing, 'Finish' button: Goes to Next Slide
- Allow user to leave quiz: After user has completed quiz
- User may view slides after quiz: At any time
- User may attempt quiz: Unlimited times
Question

Match each timer mode to its function by dragging the letters on the left to their appropriate locations on the right. Click “Done” when you are finished.

A Event Counter Mode
B Pulse Width Measurement Mode
C Pulse Period Measurement Mode
D Programmable Waveform Generator Mode
E Programmable One-Shot Generator Mode

- If an underflow occurs while the timer is counting, the TUNDF bit goes high so that the underflow can be taken into account.
- When a trigger occurs, the timer starts operating once for a given period.
- The input that the timer counts is an external signal that is fed into the MCU through the TRAIO pin.
- A signal is output from the TRBO pin and is inverted each time the counter underflows.
- After the Count Start bit has been set, the timer waits for a high signal on the TRAIO pin.

Done | Reset | Show Solution
Generating a Precise Pulse Width

- **TSTART bit in TRACR register**: Set to “1” by program, Set to “0” by program

- **Count Source**: Periodic waveforms

- **Pre-scaler RA underflow signal**: Count Starts, Timer RA primary reloads

- **Contents of TRA**: 01, 00, 01

- **IR bit in TRAIC register**: Waveform Output Starts

- **Output of TRAO out pin**: Waveform Output ends

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Programmable Wait One Shot Generation Mode: Timer RB

In this mode, upon program or external trigger input, the device outputs the one-shot pulse from the TRBO pin after waiting for a given length of time. When a trigger occurs, the timer starts outputting a pulse for a given length of time equal to the set value in the TRBSC register. This is only after waiting for the TRBPR register to overflow.

Diagram:
- Timer RB One Shot bit
- Count Source
- Prescaler RB underflow signal
- Interrupt Request bit in Timer RB Interrupt Control register
- Contents of TRBPR
- TRBO out pin

Set to "1" by program, or set to "1" by INT0 pin input trigger
Set to "0" when counting completed
Wait starts
Waveform output starts
Waveform output end
Count Starts
Timer RB secondary reloads
Timer RB primary reloads
Input Capture Mode

fOCO \rightarrow fOCO_{128} \rightarrow \text{Input capture signal}^{(3)}

\text{IOA3} = 0 \rightarrow \text{IOA3} = 1

TRCIOA

TRCIOB

TRCIOC

TRCIOD

\text{Input capture signal}

\text{Input capture signal}

\text{Input capture signal}

\text{TRC register}

\text{TRCGRD register}

\text{TRCGRB register}

\text{TRCGRC register}

\text{TRCGRA register}

\text{Divided by 128}

(Note 1)

(Note 2)

(Note 3)
TimerRC Timer Mode Output Compare

TRCIOA → Output control

TRCIOC → Output control

TRCIOB → Output control

TRCIOD → Output control

Compare match signal

 Comparator → TRC

 Comparator → TRCGRA

 Comparator → TRCGRC

 Comparator → TRCGRB

 Comparator → TRCGRD
TimerRC PWM Mode

Count source

TRC register value

TRCIOB output
Active level is “H”
“L” initial output until compare match

TRCIOC output
Inactive level is “L”
“L” initial output until compare match

TRCID output
Active level is “L”
“H” initial output until compare match

m+1
n+1
m-n
p+1
m-p
q+1
m-q
TimerRD Complementary PWM Mode
TimerRD Complementary PWM Mode
Match the timer operating mode to one of its applications by dragging the letters on the left to their appropriate locations on the right. Click "Done" when you are finished.

- Input Capture mode (Timer RC)
  - Can be used to generate a pulse that has a precise, program-controlled width

- Programmable One Shot Generation mode (Timer RB)
  - Could be used to measure the speed of a conveyor belt

- Pulse Width Measurement mode (Timer RA)
  - Useful for determining the duration of an event

- Programmable Waveform Generation mode (Timer RB)
  - Useful in motor control applications

**Properties**
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Match the timer operating mode to one of its applications by dragging the letters on the left to their appropriate locations on the right. Click “Done” when you are finished.

A. Input Capture mode (Timer RC)
   - Useful for determining the duration of an event

B. Programmable One Shot Generation mode (Timer RB)
   - Can be used to generate a pulse that has a precise, program-controlled width

C. Pulse Width Measurement mode (Timer RA)
   - Useful in motor control applications

D. Programmable Waveform Generation mode (Timer RB)
   - Could be used to measure the speed of a conveyor belt

Done  Reset  Show Solution
Watchdog Timer

The WDT circuit contains a 15-bit counter that counts down the clock derived by dividing the CPU clock by 16 or 128 using the pre-scaler.
Power-On Reset Function

- No External Reset IC required
- Internal state in Reset
- CPU Reset
- Reset Released

VCC [V]
- 0.5
- 3.8V ± 0.5V
- More Than 1ms
- (1/(f(RING))) X 32
The operation of the LVD function is essentially the same as the operation of the POR.
LVD Operation

- **VCC**
- **Vdet**
- **Internal Reset Signal**
- **Voltage Detect Flag**
- **Voltage Detect Enable**
- **Voltage Detect Interrupt Request**

- Sampling time 3 to 4 clocks
- \((1/f(RING)) \times 32\)

- Interrupt Acknowledge
Which statements describe the LVD function? Select all that apply and then click Submit.

- Causes the Voltage Detection flag to go to zero when VCC drops below the detection voltage level
- Removes the Reset and generates a Voltage Detection Interrupt request 32 On-chip oscillator cycles after VCC rises above the Vdet level
- Generates a Voltage Detection Interrupt and an internal Reset signal if VCC stays below Vdet during the sampling time of 1, 2, 4 or 8 clock cycles
- Resets the microcomputer automatically whenever it is turned on without using an external Reset circuit
Which statements describe the LVD function? Select all that apply and then click Done.

- Causes the Voltage Detection flag to go to zero when VCC drops below the detection voltage level
- Generates a Voltage Detection Interrupt and an internal Reset signal if VCC stays below Vdet during the sampling time of 1, 2, 4 or 8 clock cycles
- Removes the Reset and generates a Voltage Detection Interrupt request 32 On-chip oscillator cycles after VCC rises above the Vdet level
- Resets the microcomputer automatically whenever it is turned on without using an external Reset circuit

**Done**
Course Summary

- Timer functions
- Timer modes
- Watchdog timer
- Power-On Reset function
- Low Voltage Detect function

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