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Motor Control Using Triac

Introduction

This application note describes a simple method for controlling a motor using a triac and a means of detecting the zero crossing on 50 Hz power systems with voltages up to 230 Vac. R8C/1A is a flash MCU that provide a low cost and high performance solution for triac control. The minimum execution time for high speed instruction processing is 125ns using the on-chip oscillator. There are many other useful peripheral functions on MCU that can be used for future improvements.

Other Renesas products that used in this application example are BCR08AM-12 (Triac) and 1N4148 (Diode).

In additional to this application note, the manuals listed below are available for reference for developing applications.

Related manuals:

1. R8C/1A group hardware manual.
2. R8C/Tiny series software manual.
5. E8 user manual additional document.
6. BCR08AM-12 specification manual
7. 1N4148 specification manual
Contents

1. Application......................................................................................................................................... 5
2. Basic Triac Operation........................................................................................................................ 5
2.1 Phase Control ................................................................................................................................... 5

3. Renesas Components Specification .................................................................................................. 6
3.1 MCU .................................................................................................................................................. 6
3.2 Triac .................................................................................................................................................. 6
3.3 Diode................................................................................................................................................. 6

4. Block Diagram and Board Features ................................................................................................ 7

5. Application Example.......................................................................................................................... 8
5.1 Power Supply .................................................................................................................................... 8
5.2 Detection Circuits .............................................................................................................................. 8

6. Software Program ................................................................................................................................ 9

7. Conclusion ........................................................................................................................................ 9
1. Application

Low power triacs are used in many applications such as light dimmers, speed controls for electric fans, electric motors and control circuits of many household appliances such as washing machines, vacuum cleaners and drilling machines.

2. Basic Triac Operation

A triac is basically a bidirectional electronic switch, which can conduct current in either direction when it is triggered. The triggering can be either a positive or negative voltage applied to its gate electrode. By applying a steady state gate signal, the triac may be triggered into a low impedance state where conduction across the main terminals will occur. The gate signal polarity need not follow the main terminal polarity. Gate requirement vary depending on the direction of the main terminal current and the gate current.

Triac controlled AC switching is referenced to the AC 50 Hz line frequency, which enables precise control over the conduction angle at which the triac is fired. This enables the R8C device to control the power output by increasing or decreasing the conduction angle in each half cycle.

2.1 Phase Control

The application example uses a phase control method for controlling the amount of power delivered to the load. Phase control works by turning on a fraction of each half wave. The power delivered will be proportional to the area under the curve. The benefit of the phase control is that the frequency of the waveform providing power to the load is unchanged at 50 Hz.
3. Renesas Components Specification

3.1 MCU

Part Number: R8C/1A <R5F211A1SP; Flash ROM/RAM: 4KB/384B>

CPU: R8C 16-bit CPU Core
- Minimum instruction execution time: 50ns (When f(XIN)=20MHz)
- Power-supply voltage: 3.0 to 5.5V/ Max.20MHz
- Clock generation circuit: three circuits incorporated
  - XIN-XOUT main clock (on-chip oscillation stop detection circuit)
  - High-speed on-chip oscillator(40MHz)
  - Low-speed on-chip oscillator
- Voltage detection circuit(LVD): two circuits
- Power-On Reset(POR)
- Multifunctional timers
  - 2 ch of 8-bit timers (timer X, timer Z)
  - 1 ch of 16-bit timer (timer C)
- Serial I/O:
  - 1 ch of Clock synchronous/UART
  - 1 ch of UART
  - 1 ch of I2C bus/SSU
- A/D converter
  - 10bits x 4ch
- Ports : Input/Output : 13, Input : 3
  - No. of LED drive ports: 4
  - Pull-up resistor: All ports can be set (excluding for the input specific port)
- Watchdog timer: 1ch (supporting hardware reset)
- Packages: 20-pin SDIP (19mm x 6.3mm , 1.778mm pitch)

3.2 Triac

Part Number: BCR08AM-12

IT (RMS) : 0.8 A
VDRM : 600 V
IRGTI, IRGT : 5 mA

3.3 Diode

Part Number: 1N4148

Low capacitance. (C = 4.0 pF max)
Short reverse recovery time. (trr = 4.0 ns max)
High reliability with glass seal.
4. Block Diagram and Board Features

- Utilize R8C unique features <Power-ON Reset, High Speed On-chip oscillator> to further reduce cost on clock crystal and Reset IC.
- AC inductor motor control with technique on phase angle and zero crossing.
- Standard platform to add in future development <R8C/2J, Close loop control>

- Low cost discrete power conversion circuit
- Flash programming
- On-chip debugging

Phase control waveform
5. Application Example

The application example uses a low cost R8C/1A to control an AC motor using BCR08AM. A program is written to detect the zero crossing of the AC signal and in turn control the triac to provide power to the AC motor. This application note provides a convenient and simple solution for testing or further development for motor control using a triac.

5.1 Power Supply

The power supply circuitry is a resistive transformerless power supply. A 5V zener diode (D1) and some circuit components are used to provide 5V to the rest of the motor control board. This design is smaller and cheaper than a transformer based power supply. The fuse (F1) and varistor (V1) are used to provide additional safety protection to the power supply circuit.

5.2 Detection Circuits

For this application example, the zero crossing waveform can be detected from the power supply circuit. On the power supply circuit which provides a 5V pulse at the zero crossing point of a AC waveform, this 5V pulse will be sent to a R8C/1A hardware interrupt port <P4_5/INT>. This signal will inform the program that a zero crossing has been detected and it should start processing the conduction angle. The conduction angle is counted by means of a timer counter. After R8C/1A has reached the conduction angle or after the timer counter has stopped, the program will send a pulse to activate the triac control circuit. The triac will be fired during the conduction angle chosen by the program. The motor will be turned on at the speed determined by the time it is turned on and is proportional to the power supplied to it.

Schematic Diagram
6. Software Program

The application program will run the motor at the selected speed depending on which push button is pressed. The motor will stop when the push button is released. When the application is being turned on, the program will initialize the settings required for the interrupt and timer. After initialization, the push button will be consistently monitored for button push action. If no button is being pressed, the motor will be kept in no movement status. The interrupt will always detect zero crossing of the ac waveform whenever it occurs but no action will be taken unless a push button is pressed. When the button is pressed and zero crossing is detected, the timer will start to count towards a predefined conduction angle at a certain time. When the conduction angle is reached, the triac will be switch on and remain on until it’s half cycle ends.

7. Conclusion

This application example shows a basic and simple approach using triac control on an AC motor. It involves some simple and available designs, which can be implemented easily. Further development can be improved on the present power control circuits such as improving the current consumption of the board. Other more accurate zero-crossing detection circuits can be discussed and improved on the present detection circuit.
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