Using the HT46R47 in a Brushless DC Motor Speed Control Driver Application

D/N: HA0110E

Characteristics

- Output direct PWM drive for speed control
- 31kHz PWM frequency
- Versatile speed control inputs: PWM, VR and a thermistor input
- Operating voltage: 12VDC
- Over current protection
- Open collector hall output for speed feedback
- Locked rotor protection
- Adjustable speed

Introduction

This example is especially directed towards Brushless DC motors, with a fixed 12V control voltage. It can accept three kinds of input methods to control rotational speed, using an MCU with a PWM output to drive the motor.

A typical brushless DC motor has a wide range of applications in cooling fans, with perhaps the most abundant use seen in PC related products. This application note, which is provided for consultation purposes, shows how to use a HOLTEK HT46R47 microcontroller, in a simple example to control a cooling fan brushless DC motor.
Fan Brushless DC Motor Principles

Brushless DC motors can be subdivided into two major parts, the rotor and the stator. As their names suggest, the rotor is the rotational part of the motor while the stator is the stationary part. Structurally the stator assembly surrounds the rotor. Embedded into the side of the rotor are permanent magnets; external is the fan propeller blade. The motor coil is part of the stator assembly, and is placed inside the rotor.

Brushless DC motors utilise Hall-effect sensors to provide positional and rotational information, which informs the MCU how to drive the motor coil. In this example the single Hall-effect sensor supplies a “0” or “1” logic signal. The microcontroller, in order to control the motor coil, relies on the Hall-effect sensor output to obtain its relative positional information, which allows it to output the corresponding driver signal.

Brushless DC motors usually come in fixed voltage types, such as 5V, 6V, 12V, 24V, 48V etc., with one of the most common ones in use being the 12V type. When the motor specified fixed voltage is applied to the motor it will rotate with maximum speed, but by changing this applied voltage the motor speed can be controlled. Naturally the higher the voltage the higher the speed and vice-versa. Brushless DC motor speed is controlled by the microcontroller’s PWM output signal. This is achieved by controlling the PWM output duty cycle, which will subsequently control the motor speed.
Application Circuit Functional Description

This application example uses the HT46R47 microcontroller as the controlling device. The supplied circuit, which can be used as a reference for other applications, can be subdivided into the following sub units:

Power driver circuit, driver converter interface, protection circuits and control circuit etc.

Low Voltage Supply Circuit
The 12V DC power supply directly passes through the diode D1 to the Power MOSFET driver circuit. The 12V DC power supply is also used to generate a 5V DC power supply utilising transistor Q1 and a 5.6V zener diode, to supply power for the microcontroller control and protection circuits.

Power Driver Circuit
The Power Driver circuit is a power switch unit, whose main purpose is to drive heavier loads. In this application example, the circuit uses four Power MOSFETs devices, namely FDD 5614 and FDD6090A devices, to form a bridge driver circuit, used for driving a unidirectional Brushless DC motor.

Driver Converter Interface
The Driver Converter Interface is an interface between the microcontroller and the power driver circuit, whose main purpose is to provide voltage level shifting. This application example used two transistors Q7 and Q8 to implement the converter interface.
Protection Circuits
The protection circuits in this application example is to protect the circuit from over-current situations, thus preventing the system from overloading. The designer may also choose to add other related protection circuits for other parameters. In this circuit, when an over-current situation arises, the comparator IC3 will output a high level turning Q11 on and allowing D5 and D6 to conduct and thus keeping transistors Q5 and Q6 in an OFF state and preventing the motor from rotating.

Control Circuit
The control circuit uses a Holtek HT46R47 microcontroller, which provides the following functions:
- Detects the Hall-effect sensor signal, and determines the rotor position
- VR, NTC and PWM manage the speed control input requirement
- Provides a PWM 31kHz carrier signal output and adjusts the PWM duty-cycle to obtain the correct Brushless motor rotational speed.
- If the rotor is stuck the rotational signal will stop as a precaution
- Provides an open-collector out rotational speed signal

Software Description

MCU Peripheral Function Description
The HT46R47 microcontroller system oscillator has a frequency of 2MHz, and drives the PWM output, which then subdivides to drive transistors Q9 and Q10. With VR, NTC and the PWM and by using an A/D converter, a rotational speed control input can be implemented. IC3 forms an over-current protection comparator. When a situation of over-current occurs, the output will go high allowing Q11 to conduct, which in turn prevents the power transistors Q5 and Q6 from turning on and stopping the rotation of the motor. JP1 and JP2 are used to choose which input source is used for speed control. Q12 and Q13 are used together with the hall-effect sensor, the application software and pin PA.4 control, to supply a negative edge to generate an external interrupt signal, each time a rotation occurs.

Software Functional Description
- MCU system working frequency 2MHz
- The External Interrupt detects when the hall-effect sensor changes state
- Timer main program function is to generate a fixed time base, every 250μs generates an interrupt
- PWM carrier wave is fixed at 31kHz, and is used to control the motor speed
- AN0, AN1 and AN2 are the three A/D converter inputs, used to accept signals from VR, NTC and PWM for conversion to speed control
- Open collector output for speed feedback

Flowchart
- Main Program Flowchart

```
Initialisation

Activate Ext and Timer Interrupts

Time Exceeded?

YES

Timer Interrupted

NO

ADC Process ?

YES

ADC service routine

setup for next routine (HALL)

NO

Hall effect sensor service routine

setup for next routine (ADC)
```
Ext Interrupt Program Flowchart

EXT Interrupt Service Routine

Save ACC and STATUS registers

PA.4 = 0 ?

NO

Set PA.4 = 1

Invert Output
Reload PWM value

Clear Over Time
Timer Value

Clear PA.4 = 0

Invert Output
Reload PWM value

Restore ACC and STATUS registers

RETI
• Timer Interrupt Program Flowchart

Timer INT Subroutine

SetupTimer

Already Interrupt

MainCon.0 = 1

Reti

• ADC Converter Flowchart

ADC converter routine

ADC conversion running ?

YES

NO

Setup ADC to convert CH 0

Start ADC conversion

Setup ADC conversion

ADC CH conversion finished ?

YES

Store ADC converted value

3 Channel conversion finished

4 timers average value conversion ended?

YES

NO

Setup All CH conversion complete

Setup for next routine

Return to main program

NO

Setup for next CH
• Hall-effect sensor management
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Example Circuit
### Option Table

<table>
<thead>
<tr>
<th>Option</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SysVolt</td>
<td>5V</td>
</tr>
<tr>
<td>Package</td>
<td>18DIP</td>
</tr>
<tr>
<td>Wake-Up PA0-PA3</td>
<td>Non-Wake-Up</td>
</tr>
<tr>
<td>Wake-Up PA4-PA7</td>
<td>Non-Wake-Up</td>
</tr>
<tr>
<td>Pull-High PA0-PA3</td>
<td>PA3-PA2: Non-Pull High  PA1-PA0: Pull High</td>
</tr>
<tr>
<td>Pull-High PA4-PA7</td>
<td>PA4/PA6/PA7: Non-Pull High  PA5: Pull High</td>
</tr>
<tr>
<td>Pull-High PB0-PB3</td>
<td>Non-Pull High</td>
</tr>
<tr>
<td>Pull-High PD</td>
<td>Non-Pull High</td>
</tr>
<tr>
<td>PWM</td>
<td>ENABLE</td>
</tr>
<tr>
<td>PFD</td>
<td>DISABLE</td>
</tr>
<tr>
<td>LVR</td>
<td>ENABLE</td>
</tr>
<tr>
<td>WDT</td>
<td>ENABLE</td>
</tr>
<tr>
<td>CLRWDTS</td>
<td>One Clear Instruction</td>
</tr>
<tr>
<td>WDT Clock Source</td>
<td>WDTOSC(12kHz)</td>
</tr>
<tr>
<td>OSC</td>
<td>Crystal</td>
</tr>
</tbody>
</table>