

# Flap Motor Control Based On HVAC Platform

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## Contents

## 1 Introduction

According to the world market for electrical motors in automotive applications, there will be around 38 motors per car on an average by 2016, 80% of the motors are DC brushed type. Flap motors which include stepper and servo motors are widely used in Automotive heating, ventilation, and air conditioning (HVAC) systems. Flap motors are used in air mix control, air circulation control, outlet mode control functions for automotive HVAC applications.

1	Introduction.....	1
2	Flat Motor Type.....	1
3	Hardware Design.....	6
4	Software Design.....	7
5	Reference.....	9

## 2 Flat Motor Type

### 2.1 Stepper Motor

#### 2.1.1 Description

Stepper motor is an electromechanical device which converts electrical pulses to discrete mechanical movements.

## Flap Motor Type

The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence.

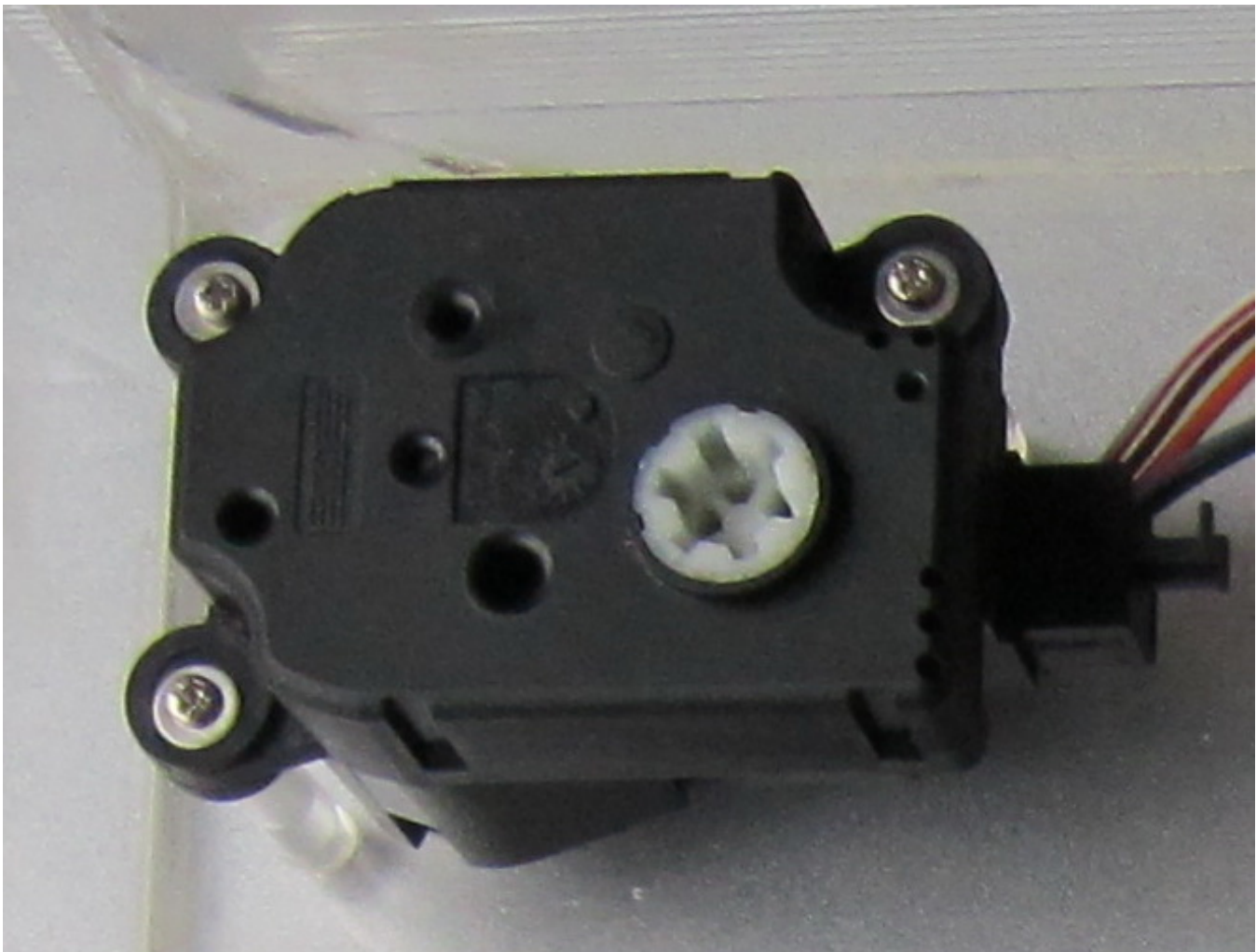
The motor rotation has several direct relationships to these applied input pulses.

The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the steps of rotation is directly related to the number of input pulses applied.

### 2.1.2 Control Port

The stepper given below in Figure 1 which used in HVAC platform is the 2 phase/5 wire type stepper motor, the connection is as given below:

1. Common line: connected to GND or 12V DC
2. 4 drive lines: connected to power drive as A, A~, B, B~



**Figure 1. Stepper Motor**

## 2.2 Servo Motor

## 2.2.1 Description

The servo motor is actually an assembly of three parts: a normal DC motor, a gear reduction unit and a position-sensing device.

The function of the servo is to apply power drive to its DC motor until its shaft turns to the expected position. It uses the position-sensing device to determine the rotational position of the shaft, so that it knows which way the motor must turn to move the shaft to the commanded position.

The shaft typically does not rotate freely round and round like a DC motor, but rather can only turn 200 degrees or so back and forth.

## 2.2.2 Control Port

Servo motor in Figure 2 used in HVAC platform is 2 poles servo motor, connection is as given below:

1. 2 drive line: connected to power drive as D/D~;
2. 5V DC: connected to 5V supply to position sensing circuit;
3. Feedback: connected to MCU ADC input;
4. GND: connected to GND;

Typical servo has a 5 wire connection as given below: 2 power drive, 5V DC, ground and position feedback.

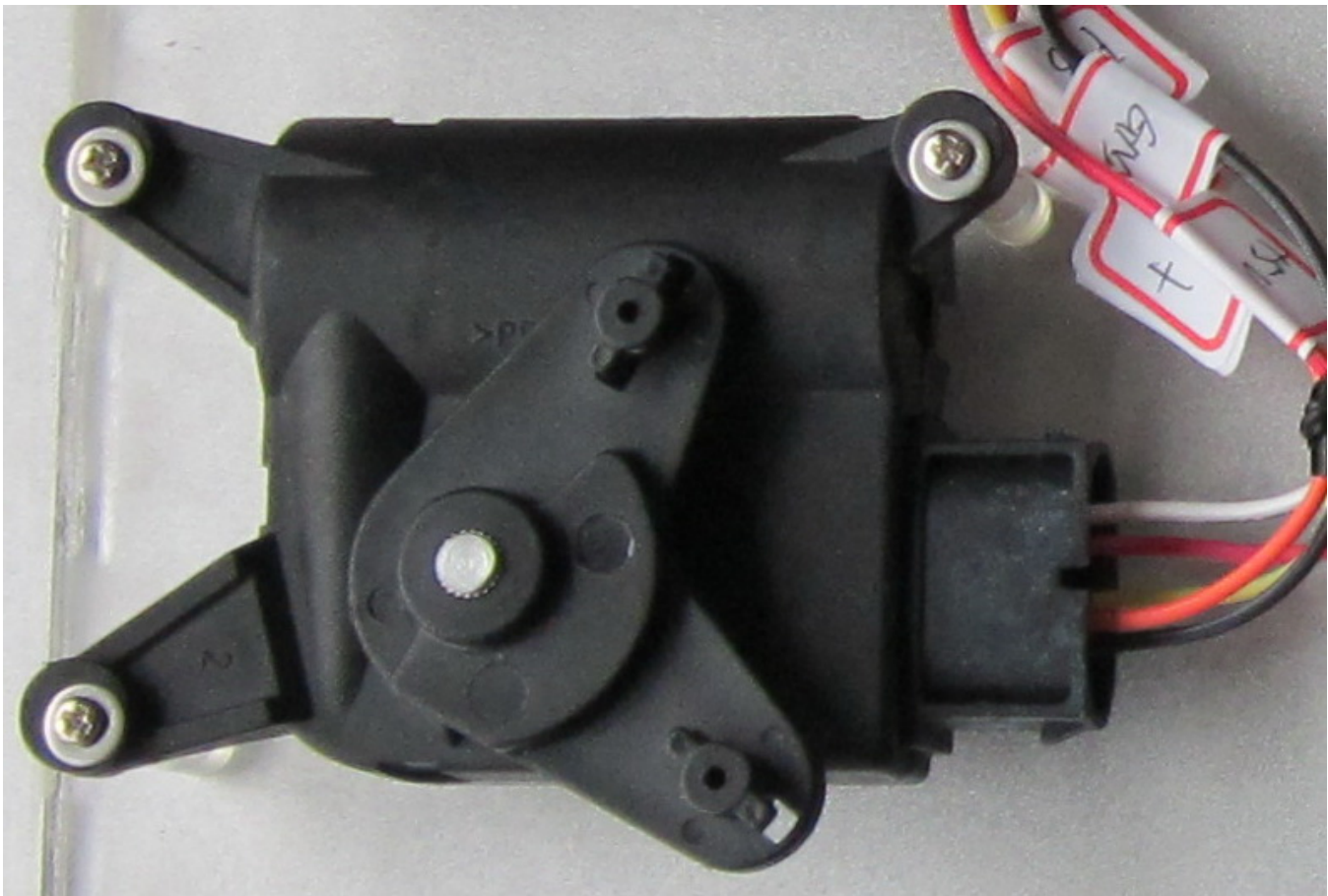


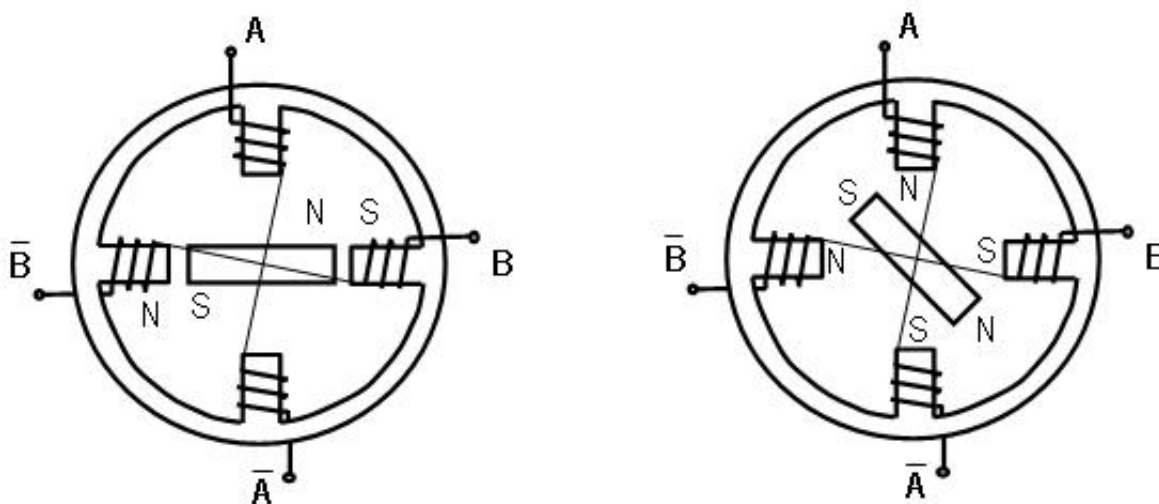
Figure 2. Servo Motor

## 2.3 Flap Motor Control Theory

### 2.3.1 Stepper Motor

#### 2.3.1.1 Stepper Motor Basics

The stepper motor inner structure is as given below:



**Figure 3. Stepper Motor Illustration**

As listed in Figure 3, A, A~ as connected group\_a, B, B~ as connected group\_b.

In two phase 4 wire/5 wire/6 wire stepper motor, inner structure is the same as listed and the difference is that whether or not common node exists for group\_a and group\_p.

Phases : number of coil poles to N,S magnet field, is indicated as m.

Steps: number of pulses to finish one cycle magnet change or rotate one gear angle of motor, is indicated as n(n is related to m).

Gears:gear number of the motor, is indicated as J. Step Angle: the rotated angle of the motor rotor while applied on one pulse, is indicated as  $\theta$ .  $\theta=360/ ( J(\text{gear number}) * n(\text{steps}) )$  .

#### 2.3.1.2 Stepper Motor Control

The sequence of the applied pulses is directly related to the direction of motor shafts rotation. Stepper motor drive could be 8 or 4 step control for 2 phase/5 wire stepper motor.

1. 8 step control

**Table 1. 8 Step Control**

	A	B	C	D	E	F	G	H
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*Table continues on the next page...*

**Table 1. 8 Step Control (continued)**

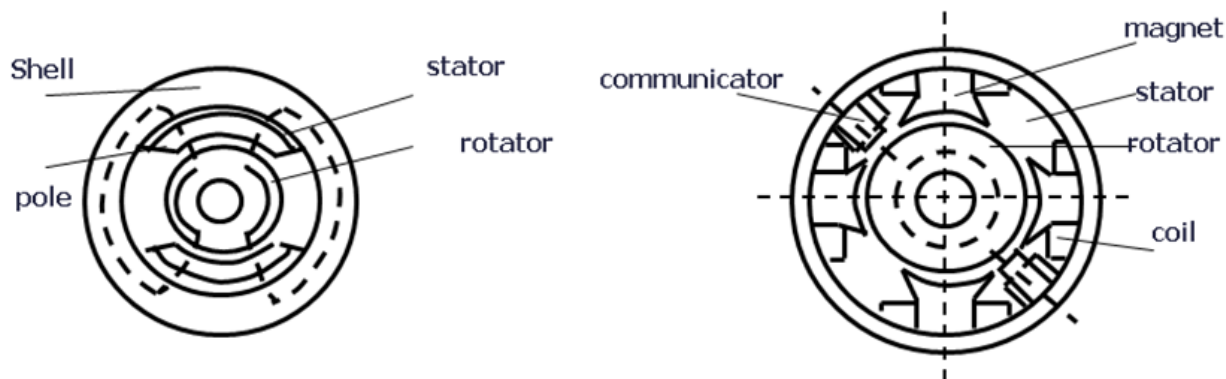
A	1	1	0	0	0	0	0	1
A~	0	0	0	0	1	1	1	0
B	0	1	1	1	0	0	0	0
B~	0	0	0	0	0	1	1	1

**Table 2. 4 Step Control**

	A	B	C	D
A	1	1	0	1
A~	0	0	1	0
B	1	0	0	0
B~	0	1	1	1

## 2.3.2 Servo Motor Control

### 2.3.2.1 DC Motor Control Basics


**Figure 4. Servo Motor Mechanical Structure**

Servo motor structure is as given above in Figure 4, if suitable DC power is applied to the coil of stator, the motor will rotate continuously, commutator will take effect inside of servo motor.

At the same time, the feedback voltage signal will be in the range of 0-5V, and it will be corresponding to the rotator position of the servo motor.

**Table 3. Servo Motor Control**

	Clockwise	Anti-clockwise	Static
D	1	0	0
D~	0	1	0

### 3 Hardware Design

#### 3.1 Control Signal

Flap motor control signals are given in Figure 5.

For each servo motor, control signals are as given below: IN1\_SMx,IN2\_SMx,EN\_SMx,/INT\_SMx,DCMx\_ADC.

For each stepper motor(2 phase/5 wire), control signals will be IN1\_SMx,IN2\_SMx, EN\_SMx,/INT\_SMx, IN1\_SMy,IN2\_SMy, EN\_SMy,/INT\_SMy.

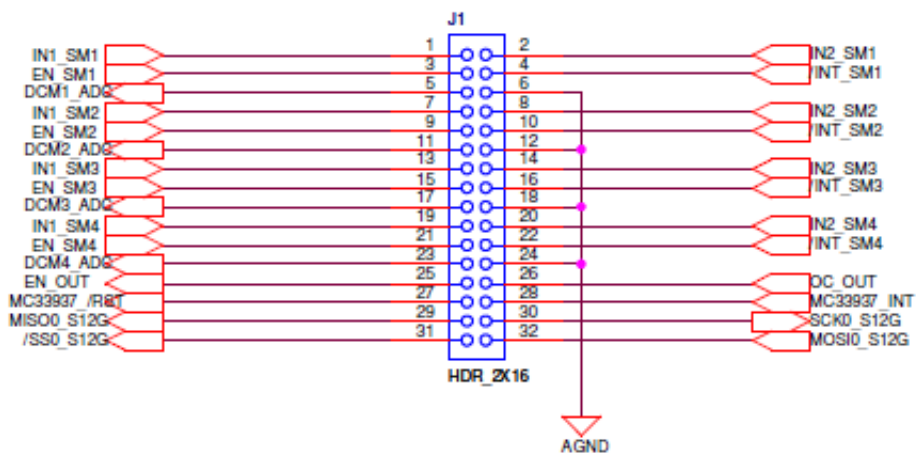


Figure 5. Flap Motor Control Signals

#### 3.2 Motor Drive and Protection

MC33932 control signals are given in Figure 6.

For each drive pair such as OUT1\_SMx,OUT2\_SMx, if current in the drive path is exceeding the limitation, the /SFA will generate an interrupt(high to know), then MCU will acknowledge the level change and stop the drive signals.

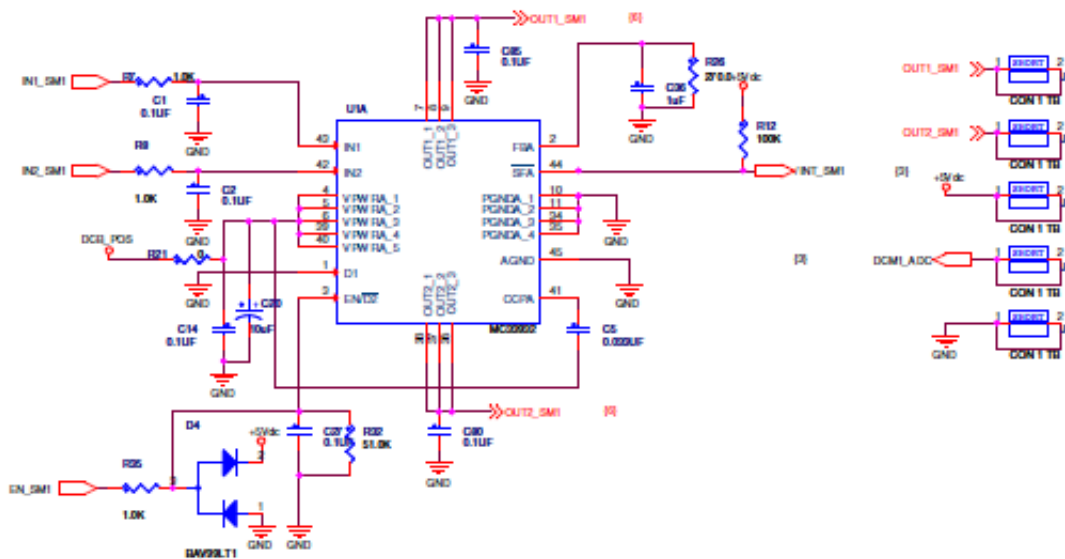


Figure 6. MC33932 Control Signals

## 4 Software Design

### 4.1 Basic Concepts

In the HVAC platform, it uses mc33932 H-Bridge Power IC to control flap motor.

One mc33932 IC can control two servo motors or one step motor respectively, signals are listed in the table given below:

Table 4. HW resources used for flap motor

HW Resources	Usage	Step Motor	Servo Motor
One periodic timer	Control Motor run/stop	Y	Y
Enable/Disable PIN	Control H-Bridge of MC33932	Y	Y
GPIO Interrupt	Report HW over-current protection	Y	Y
D/D~: 2 GPIO PINs	Control servo motor direction	N	Y
ADC	Get current motor position	N	Y
A,A~,B,B~: 4 GPIO PINs	Control step motor move	Y	N

### 4.2 Control Algorithm

All operational way to stepper motor and servo motor are asynchronous.

### 4.2.1 Servo Motor

In the HVAC platform , it uses D/D~ and one ADC channel to control one servo motor.

1. Sample the voltage value by ADC, and this value is proportional with motor position.
2. Drive high to D pin and low to D~ , motor will rotate clockwise, vice versa.
3. Once the Motor reaches the position with specified ADC feedback, then stop driving the coil, motor will stop immediately.

### 4.2.2 Step Motor

In the HVAC platform, it uses the full step drive two phases each time.

1. PWM period decides the motor speed, since PWM resource is limited, it uses periodic timer to generate the PWM(50% duty) and every timer interrupt will trigger phase change.
2. The phase change order for clockwise is: AB -> A~B -> A~B~ -> AB~ . For anticlockwise: AB -> AB~ -> A~B~ -> A~B.

## 4.3 Control Flowchart

The control flowchart given in Figure 7 shows how after initializing the hardware resources, system software will monitor the motor position in the timer interrupt and decides how to control motor in next step.

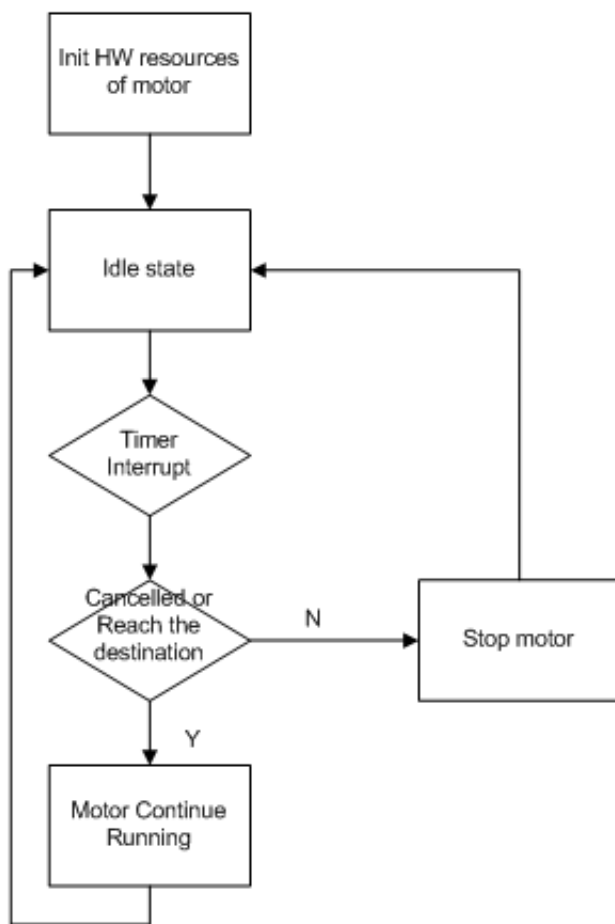


Figure 7. Stepper Motor



## 4.4 Software Protection

When over-current happens, MC33932 will produce an interrupt. Motor driver will stop motor and report this event to upper level.

## 5 Reference

- MC9S12GRMV1 Rev.1.10 February 10, 2012
- MC33932 Rev. 3.0, 1/2009

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