

Lecture 2. Stepping motor control

New Technology Company(N.T.C)

<http://www.NewTC.co.kr>

DAEWOO RYU

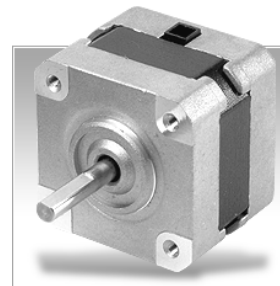
davidryu@newtc.co.kr

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1. What is stepping motor?

Stepping motor is controlled step by step. There is four motor phase, so it rotate step by step. It normally rotates 1.8° at one step..

Stepping motor is cheaper than AC servo and DC servo, and is good to control exact degree, so we can see easily in our environment.



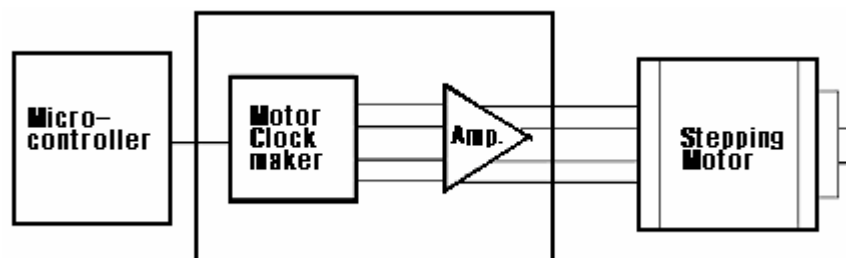
Stepping motor is possible to control with digital pulse, so is suitable for microcontroller. Stepping motor do not need to feedback for detecting the position of motor because it can rotate very exactly same degree, and it can stop with very high precision, and after applying, initial performance is satisfied, then variation by year is less, and repairing is easy, and it can be helpful to make highly reliable system.

Also, compared with other kind of motors, it has very highly holding torque, it does not need electronic brake system, and also rotating speed is proportional to pulse rate, so user can control easily

2. Controlling stepping motor

DC motor has very simple circuit, but controlling method is complicated, but relatively stepping motor has complicate circuit, but controlling is easier than DC motor.

To control stepping motor, you can use L297 and SLA7024 together. L297 makes phase for controlling stepping motor, and SLA7024 amplifies voltage and current of made phase.



The part of stepping motor

- ✓ Motor clock maker Making excitation phase of Stepping motor
- ✓ Amplifier Amplifying motor input signal, and controlling stepping motor

Operation of stepping motor

1. making clock controlling stepping motor
2. making of stepping signal for controlling stepping motor on a basis of input clock
3. Amplifier can transfer output signal from motor clock making part to motor

3. **Controlling method – partition by the flow of current**

1. Unipolar control

One transistor is connected to each coil, and ON of transistor can make flow current to each coil, and current flows just in one way at the same time. (A -> Com, A' -> Com, B -> Com, B' -> Com). That is why unipolar control.

2. Bipolar control

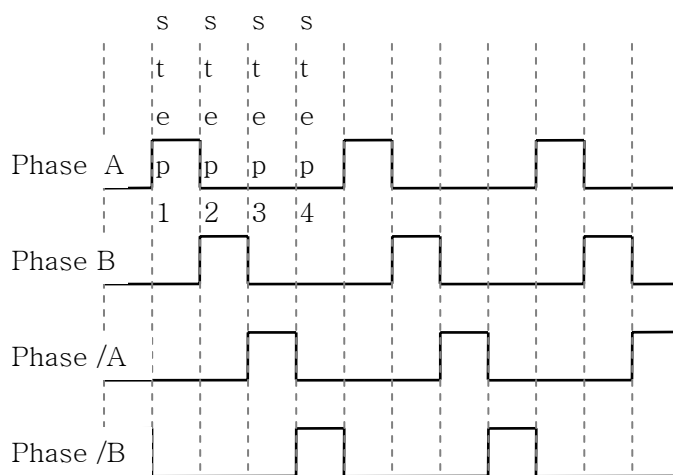
In addition to unipolar control, there is bipolar control to upgrade torque in the region of low speed, but the circuit for this is more complicated. This bipolar control drives the coil of motor flows the current in turn. I do not make a lecture at this time about this.

@ Controlling method – by excitation method

Controlling methods of stepping motor differ from how to drive current in coil. This is different from What kind of motor. I explain with PM type stepping motor with step 90°. Most basic structure of stepping motor is similar

Over here, A, B, /A, /B signal input moves electromagnet. Signal input as the followings make electromagnet connected to axis to move..

1. Phase 1 excitation method of Phase 4 motor



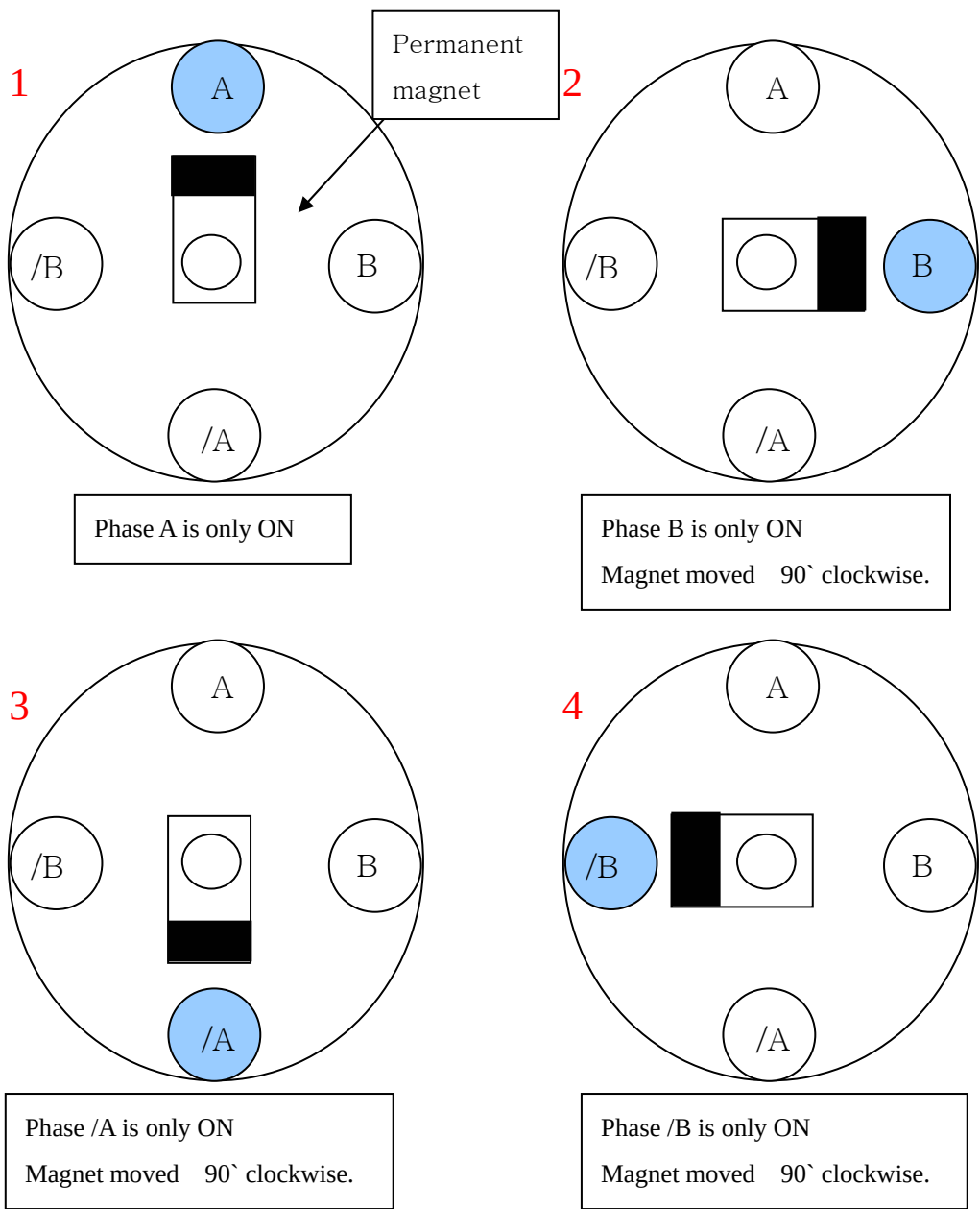
This picture presents motor signal for phase 1 excitation method.

TR connected to Step 1 phase A becomes on, and the current flows A->Com. As the current flows in the coil, the phase of the fixed magnet excite to N,S. At this time, B doesnot flows, so the phase of B is not excited, but excitation of A makes permanent magnet to stop in stable position because N, S and S,N combined.

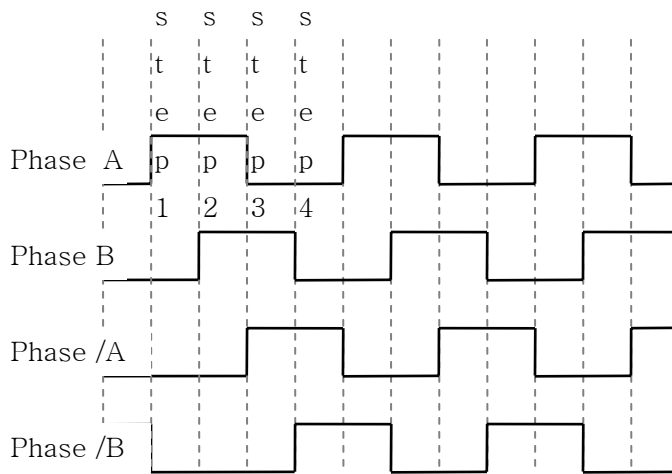
At next step, TR connected to A becomes off, and TR connected to B becomes on, and the coil current of B -> Com flows, and the fixed magnet excite, and rotator moves 90°.

With the same method, step 3 and step 4 moves, and motor can rotate 90° step by step.

Let's see the following pictures to understand this.

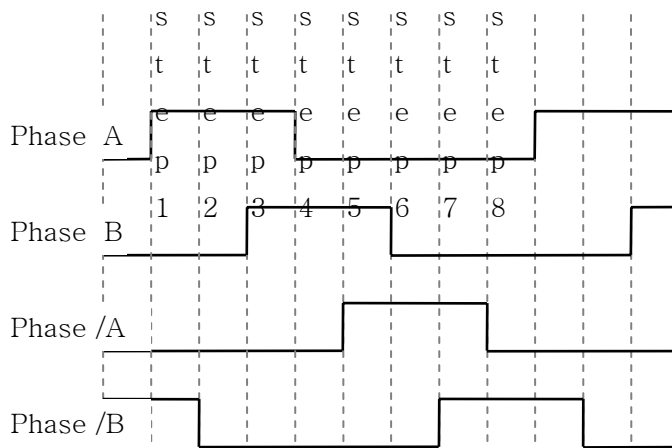


2. Phase 2 excitation method of phase 4 motor



Basic control is same to phase 1 excitation method. The difference is controlling two coils together to upgrade torque. It needs more current, but has small overshoot and undershoot when it stops, and has good excessive response.

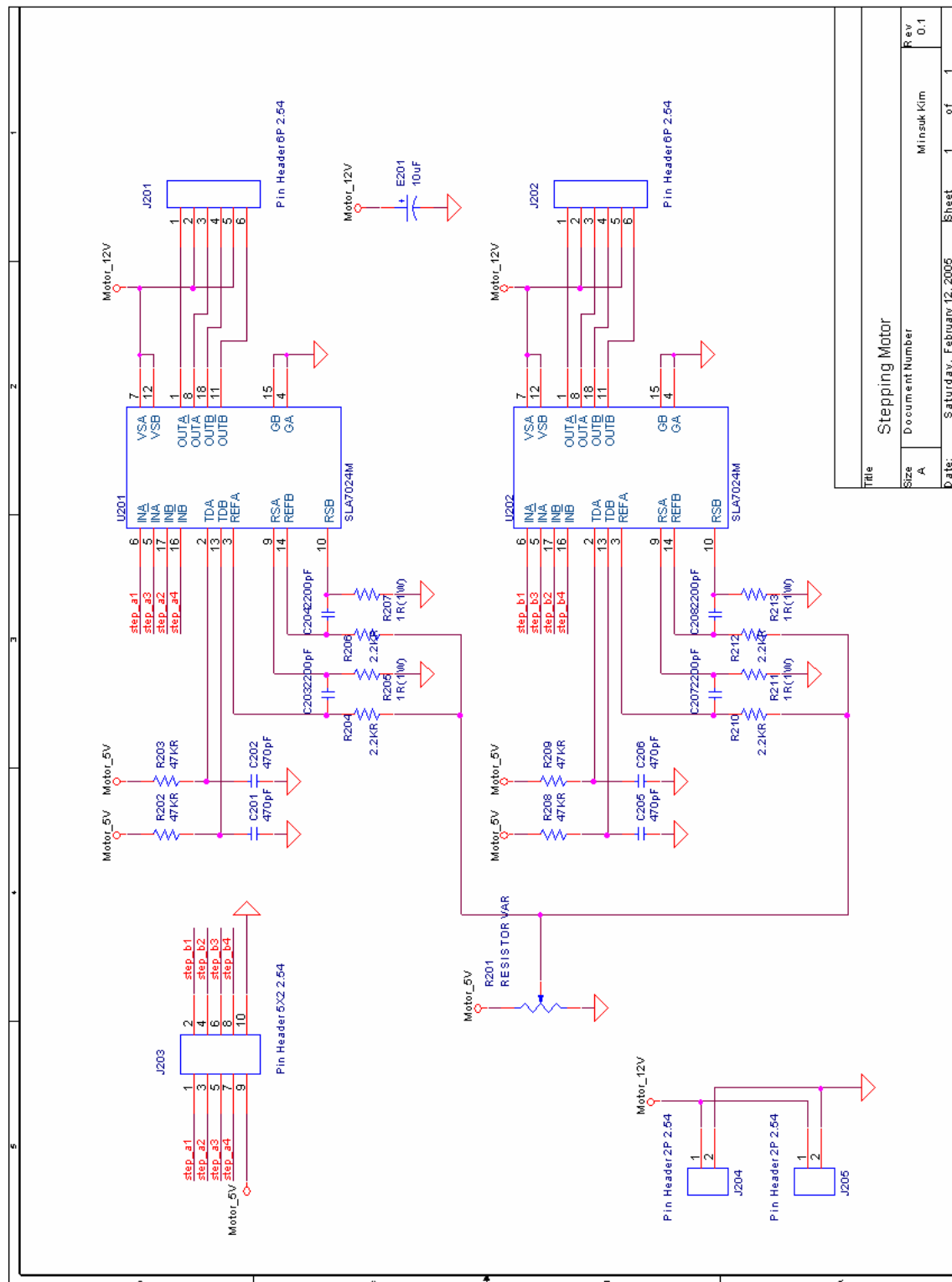
3. Phase 1-2 excitation method of phase 4 motor



Phase 1-2 excitation method repeats Phase 1 excitation method and Phase 2 excitation method in turn, so rotator rotates 45° step by step. It means it can move 1/2 times angle of maker specs. Phase 1-2 excitation method has the characteristic of Phase 1 excitation method and Phase 2 excitation method together, so step rate becomes double. The angle of step is smaller than others about 1/2 times, so it has best performance, but to make the same speed with other excitation method, you need to make double clock speed.

4. Hardware

Circuit board for stepping motor control module.



Circuit description

J203 is connector for motor control signal. Motor control signal comes from microprocessor. Control signal is inputted by U201, U202 SLA7024(7026), and these chip amplifies motor control voltage. Amplified signal is connected to J201과 J202, and it controls motor.

R201 is variable resistor for controlling the current of motor. If you rotate it, you can fix the current for torque of motor.

Other resistor and capacitors are the basic circuit of SLA7024.

Formation part of Motor clock can be made by chip only, but we can also make by microprocessor, so I composed hardware only in amplifier, and I programmed with MCU F/W software.

부품 List

Part	Reference	Quantity
470pF	C201,C202,C205,C206	4
2200pF	C203,C204,C207,C208	4
10uF	E201	1
Pin Header 6P 2.54	J202,J201	2
Pin Header 5X2 2.54	J203	1
Pin Header 2P 2.54	J205,J204	2
가변저항 500 Ohm	R201	1
47KR	R202,R203,R208,R209	4
2.2KR	R204,R206,R210,R212	4
1R (1 Watt)	R205,R207,R211,R213	4
SLA7024M	U201,U202	2

5. MCU Firmware programming

```
step      current output value for motor

switch(step){
    case 0x03 : step = 0x06;  break;
    case 0x06 : step = 0x0c;  break;
    case 0x0c : step = 0x09;  break;
    case 0x09 : step = 0x03;  break;
    default   : step = 0x03;  break;
}

step      : next motor output
```

If I use this upper routine one time, motor rotates 1.8°. If I use this routine with Timer interrupt routine, motor moves in the speed of timer. You could use upper routine to rotate motor. At first, rotate motor with delay statement as a test.

```
void main (void)
{
    char step = 0;
    while(1){
        step = nextMotorCLK(step);           // you could refer to upper' switch case.'
        PORTD = step;                        //Output signal is connected to PORTD
        Delay(100);
    }
}
```

Until now, I just checked whether motor rotates or not to check motor controlling circuit, and the status of motor.

As a next stage, I should control with Timer Interrupt. After studying about timer interrupt, and test it

6. Epilogue

At last time, I used to make with hardware with IC(L297), but nowadays I make steps without Formation part of Motor clock, and output to amplifier directly Hardware and software acts their own role

Phase 1-2 excitation method has the most small angle to move at one clock, so it makes motor move smoothly, so you'd better to use Phase 1-2 excitation method.