

# 1111\_電機械固態控制 AC & DC DRIVERS

實作講義6

六步方波120度導通驅動法

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Handout 6

120 degree conduction

Six-step square wave drive mode

2022/11/01



成功大學  
National Cheng Kung University

## Handout 6

# 上課準備

- 請至moodle下載教學用檔案。
- Please download the handouts from moodle.



Handout 6

大綱

**Test Board**

**Code SixStep**

**Drive Table**

**Homework**



## Handout 6 Import Project

匯入程式後請設定使用的晶片及連接方式。參考實作講義2。

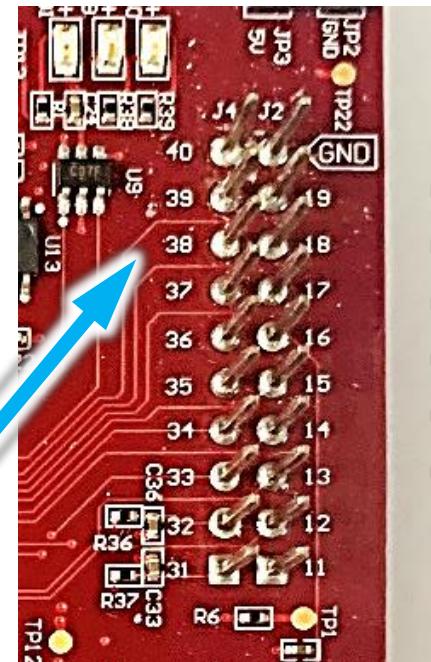
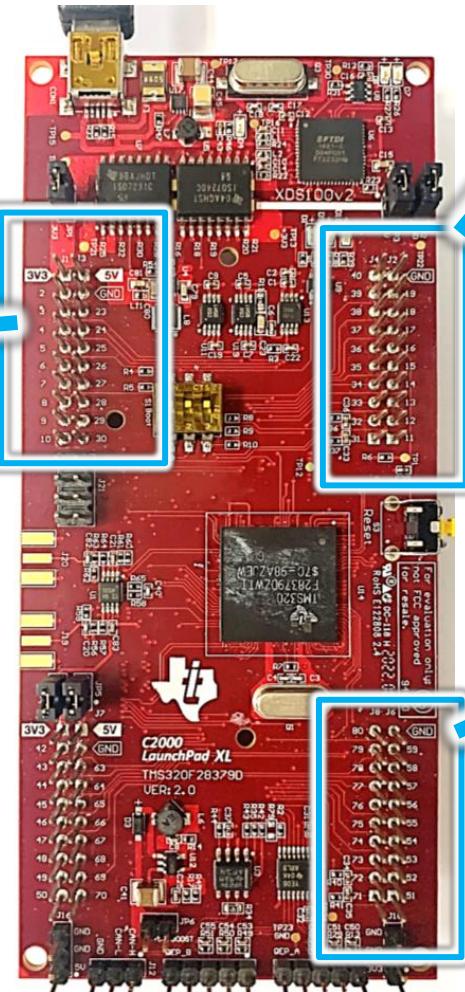
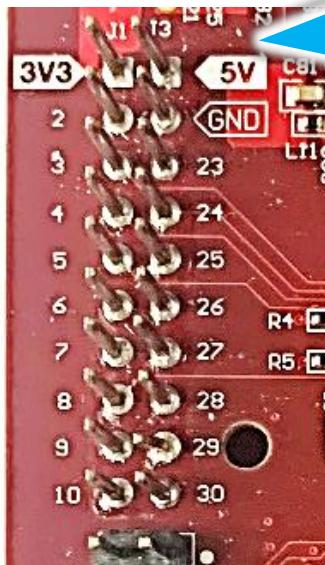
Please check target and connection after import, ref to Lecture2.



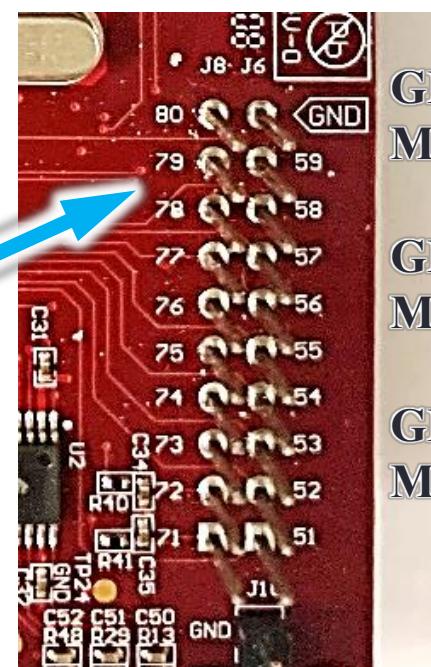
# Handout 6 Test Board

## LAUNCHXL-F28379D Overview (Rev. C)

3.3 V \_pin01  
5 V \_pin21  
GND \_pin22



**GPIO0\_pin40\_U+**  
**GPIO1\_pin39\_U-**  
**GPIO2\_pin38\_V+**  
**GPIO3\_pin37\_V-**  
**GPIO4\_pin36\_W+**  
**GPIO5\_pin35\_W-**



**GPIO6\_pin80\_MOTOR YELLOW LINE**

**GPIO7\_pin79\_MOTOR ?????? LINE**

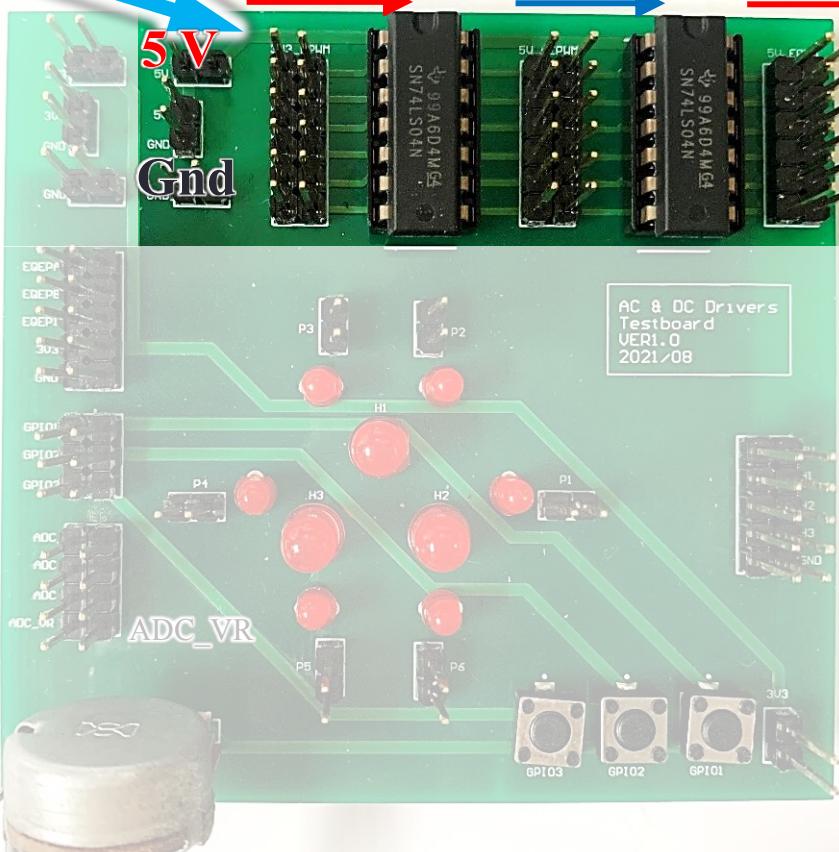
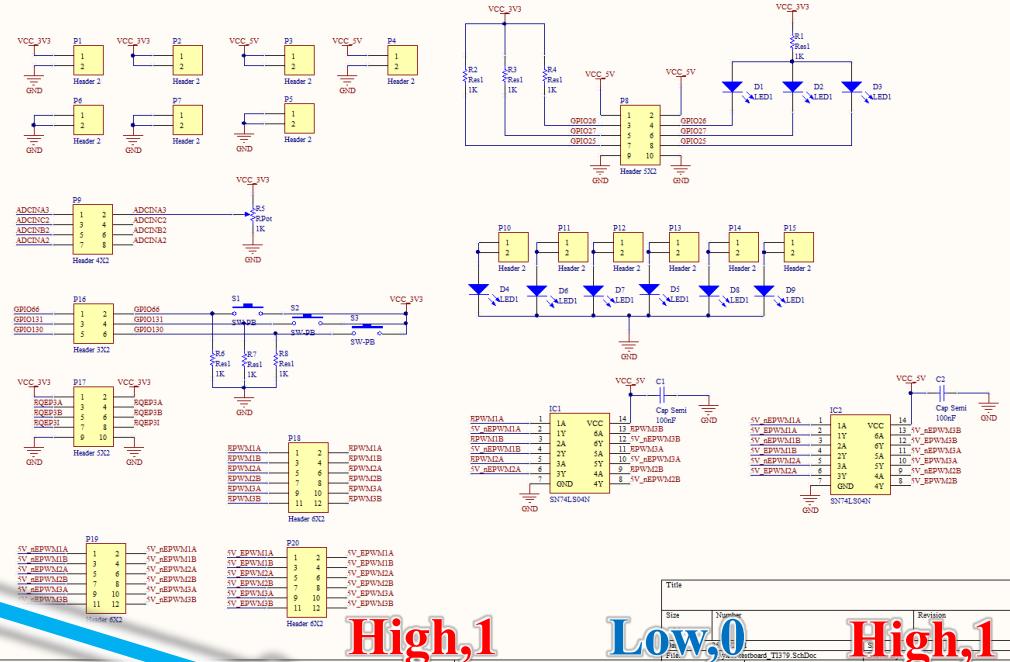
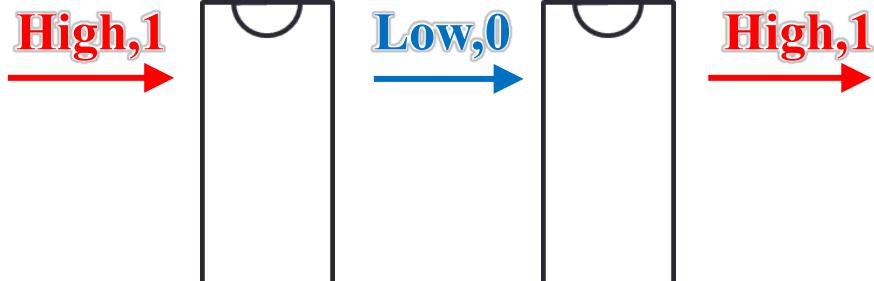
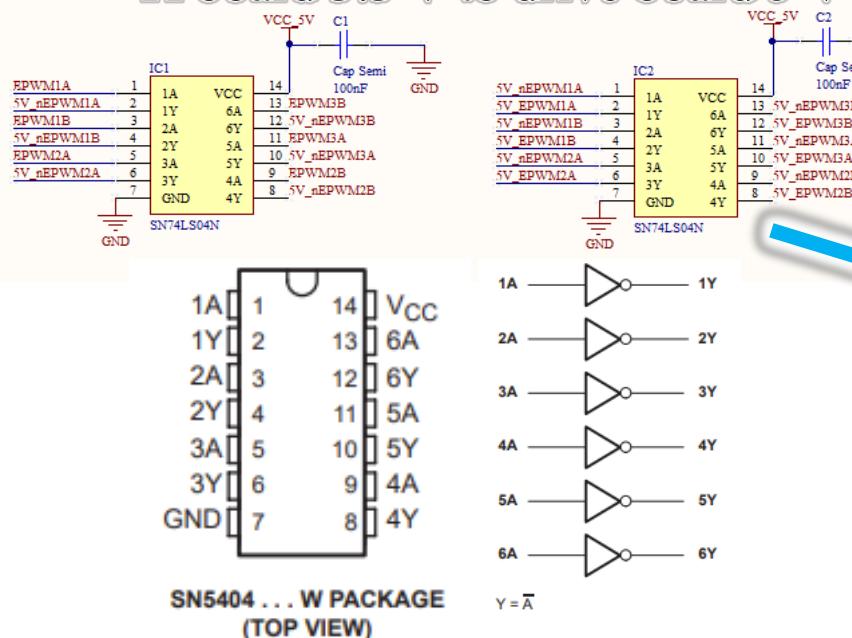
**GPIO8\_pin78\_MOTOR ?????? LINE**



# Handout 6 Test Board

# INVERTER SN74LS04N

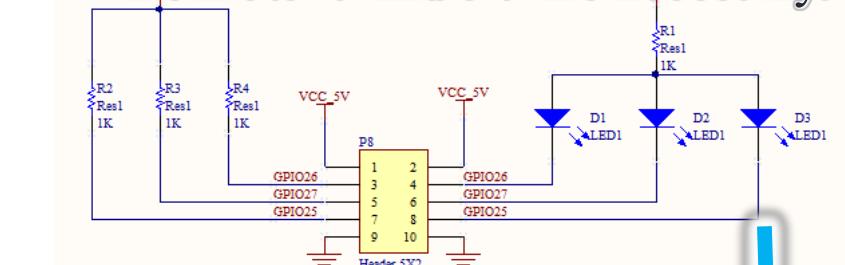
# TI board 3.3 V to drive board 5 V



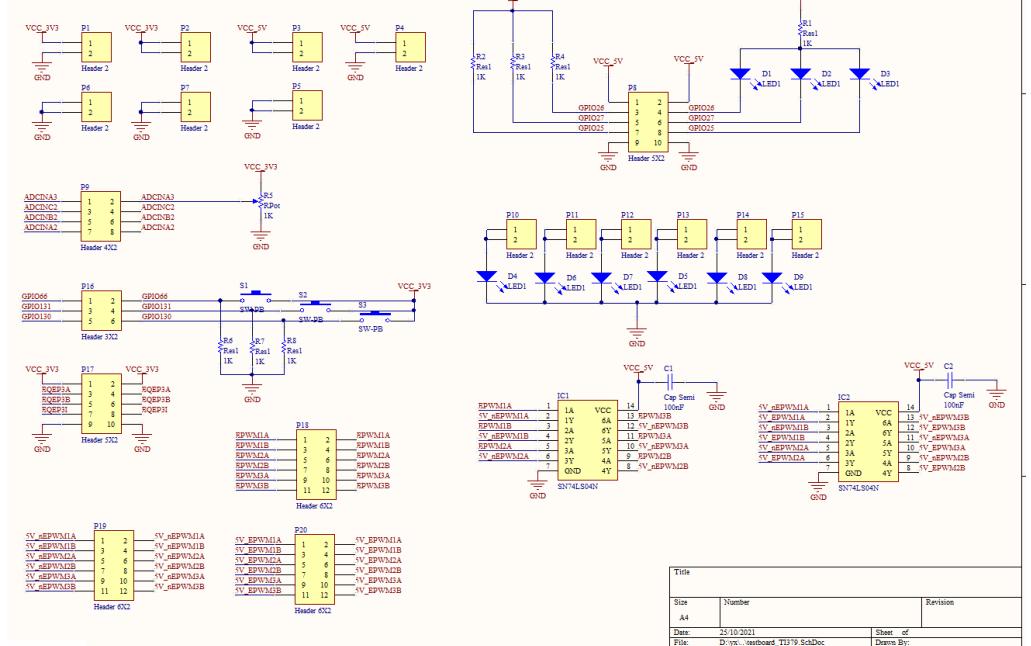
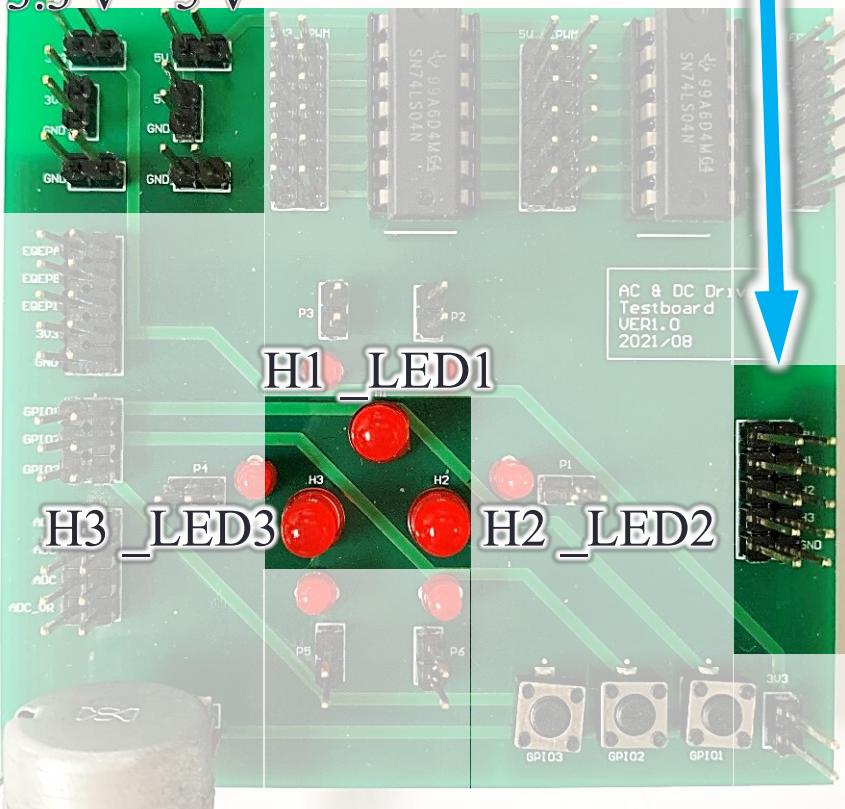
# Handout 6 Test Board

Pull up resistor with LED.

Both 3.3 V and 5V are necessary.



3.3 V    5V



motor \_orange line \_ 5 V for hall IC  
motor \_black line \_ Gnd for hall IC

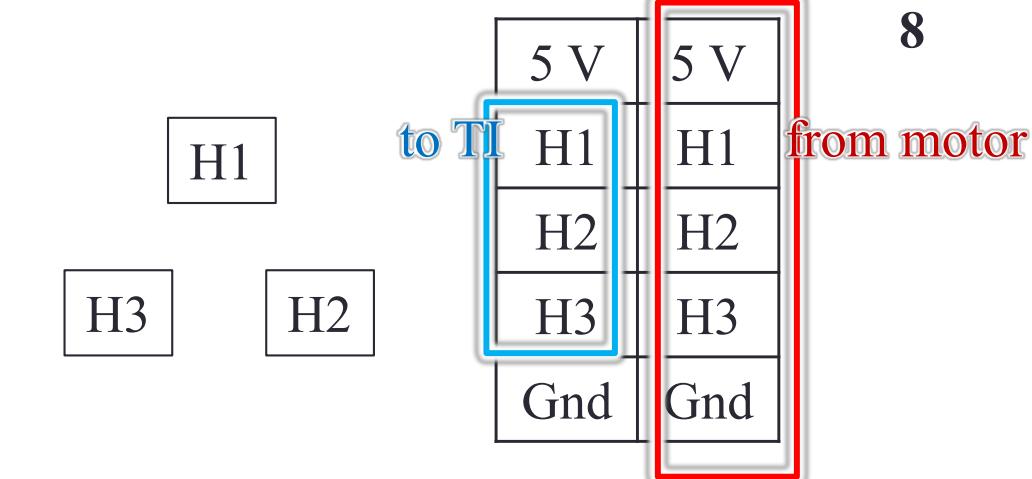
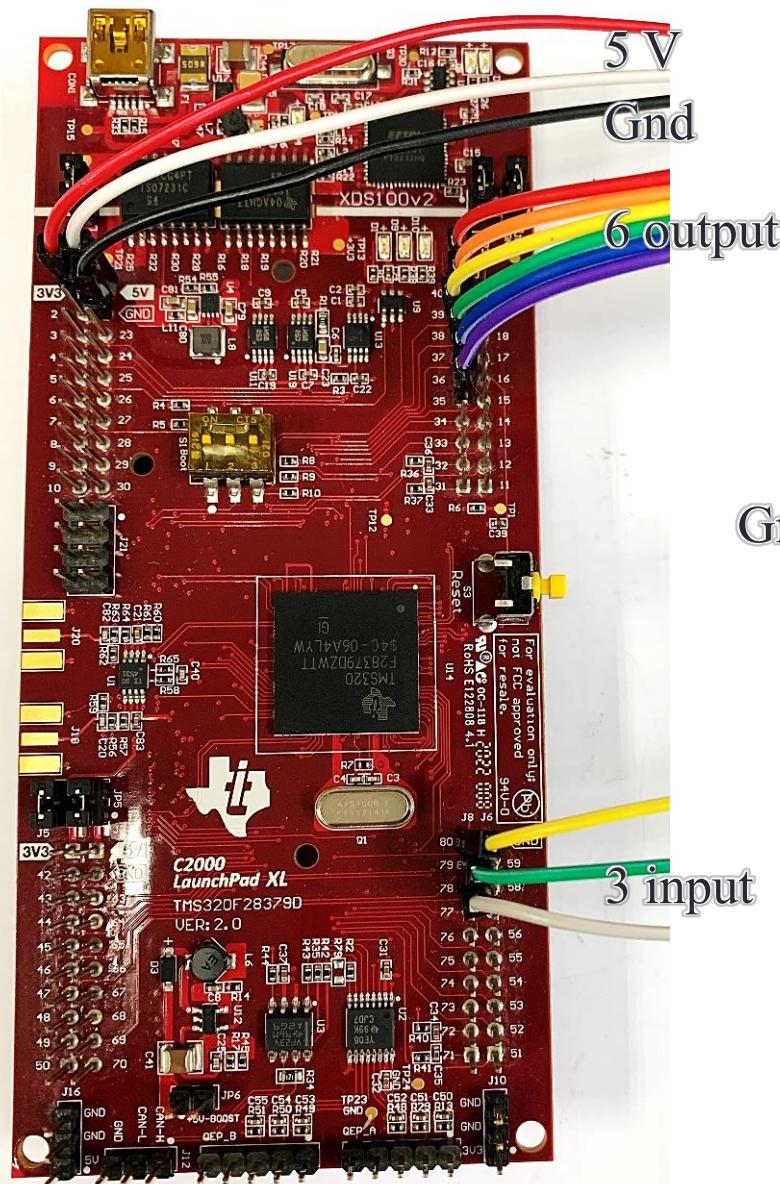
5V  
H1\_LED1  
H2\_LED2  
H3\_LED3  
Gnd



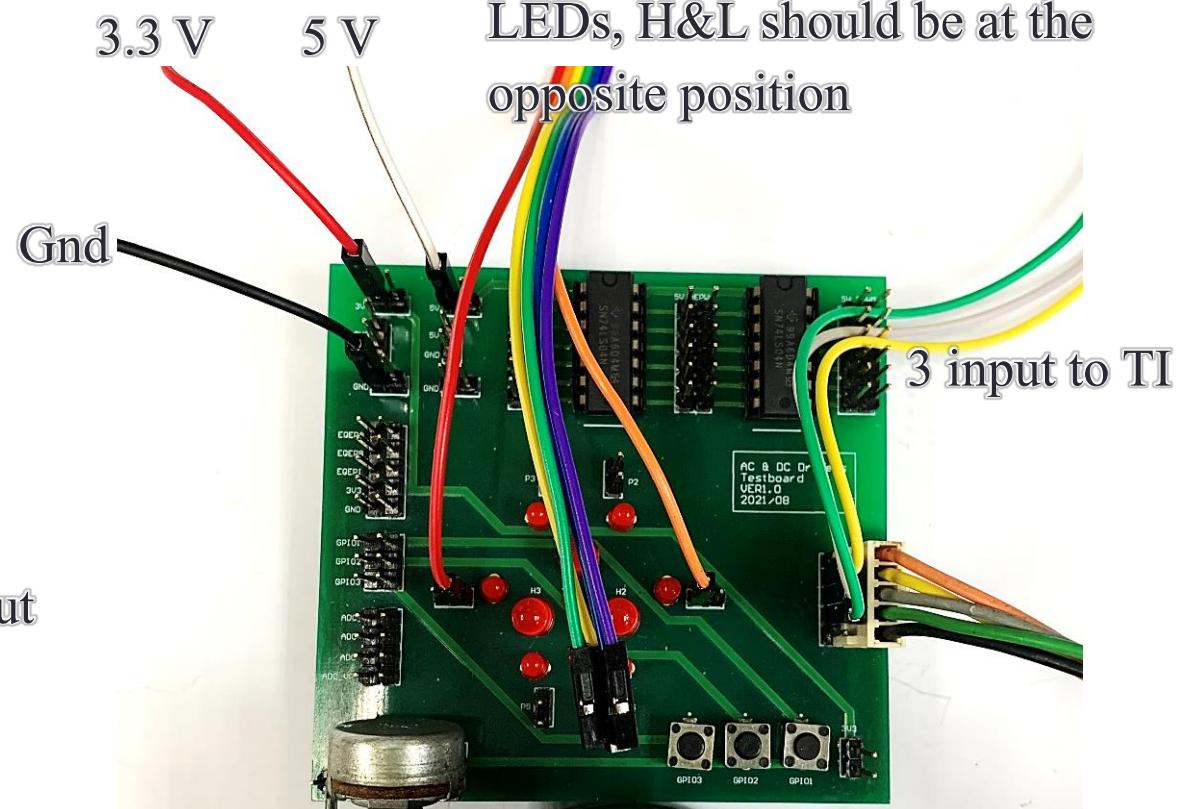
The yellow, green and gray wires of the motor are Hall signals, connected to the H1, H2, and H3 pins, each with 1 LED to display ***the status of the Hall IC***

# Handout 6 Test Board

Hall signal test :

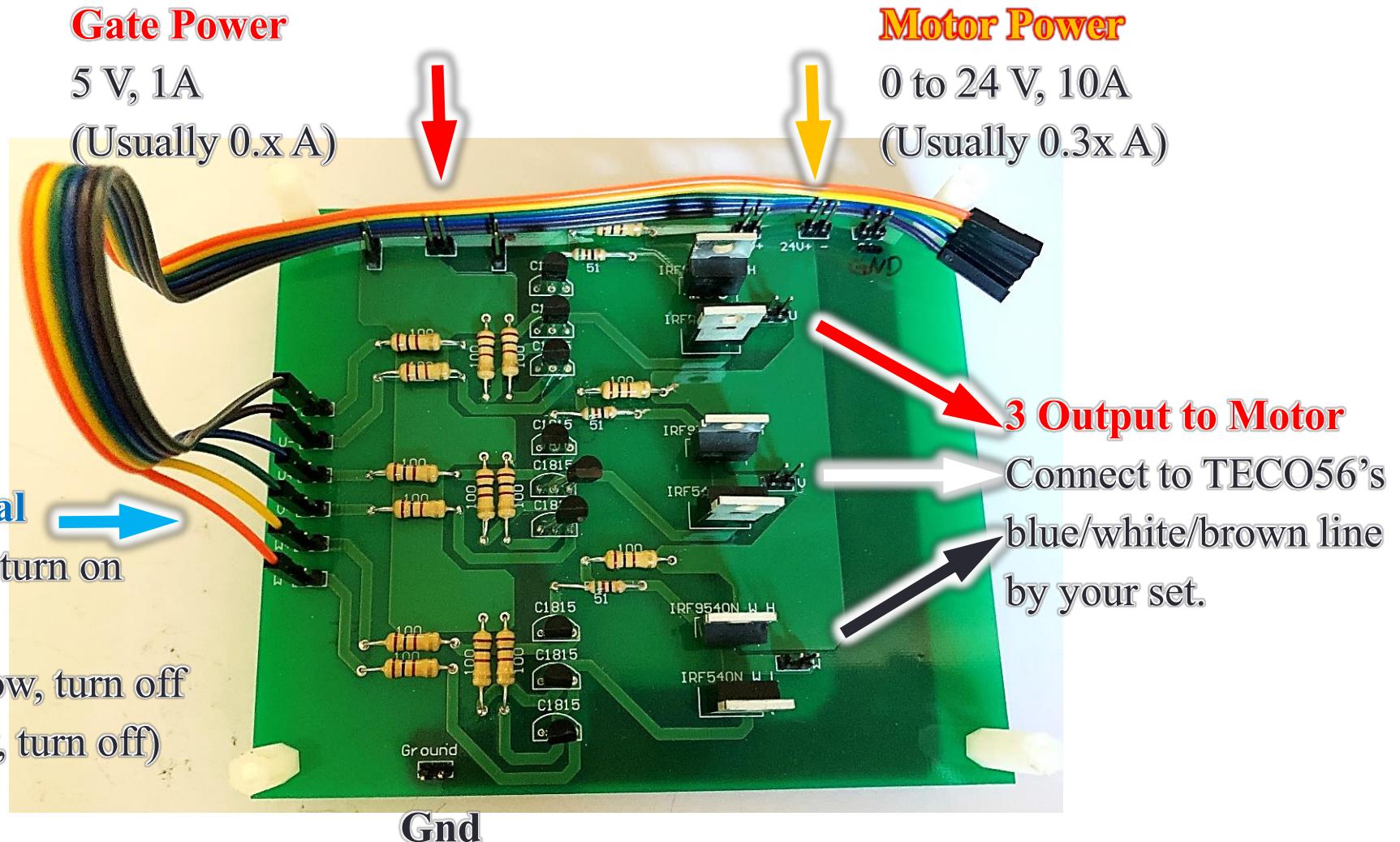


6 outputs are set to 6 small LEDs, H&L should be at the opposite position



# Handout 6 Test Board

Drive board (up\_IRF9540N\_to\_IRF540N\_down)



# Handout 6 Test Board

實驗的注意事項：

多想，就會發現問題。

有問題就試著問，電路沒在跟你可能大概應該的。

想清楚了，先嘗試告訴隊友或助教你接下來要做什麼。

實驗前，務必檢查儀器歸零，以及接線正確。

實驗時，上電須有助教在場並同意。

實驗中，多做實驗記錄，沒有實驗記錄那什麼實驗都是白做。

實驗中，有問題發生時，第一個關的是主電源。絕對不要先下程式。

實驗後，記得歸零儀器。

紀錄用品：紙筆，手機，USB隨身碟，螢幕錄影程式...其他。



# Handout 6 Test Board

Notes for the experiment:

Think hard, find the problem.

Try to ask, if there is a questions. Circuit won't "maybe, probably, should" work.

After thinking it through and before taking action, please try to tell your teammate or TAs what you are going to do next.

Before the experiment, be sure to check that the instrument is reset to zero and the wiring is correct.

During the experiment, only when TA agrees then power can be turn on.

During the experiment, remember to make more experimental records.

If there is no experimental record, all experiments are meaningless.

In the experiment, when a problem occurs, the main power supply is turned off first.

Never terminate the program first.

After the experiment, remember to reset the instrument to zero.

Recording tools: paper and pen, mobile phone, USB disk, screen recording program... others.

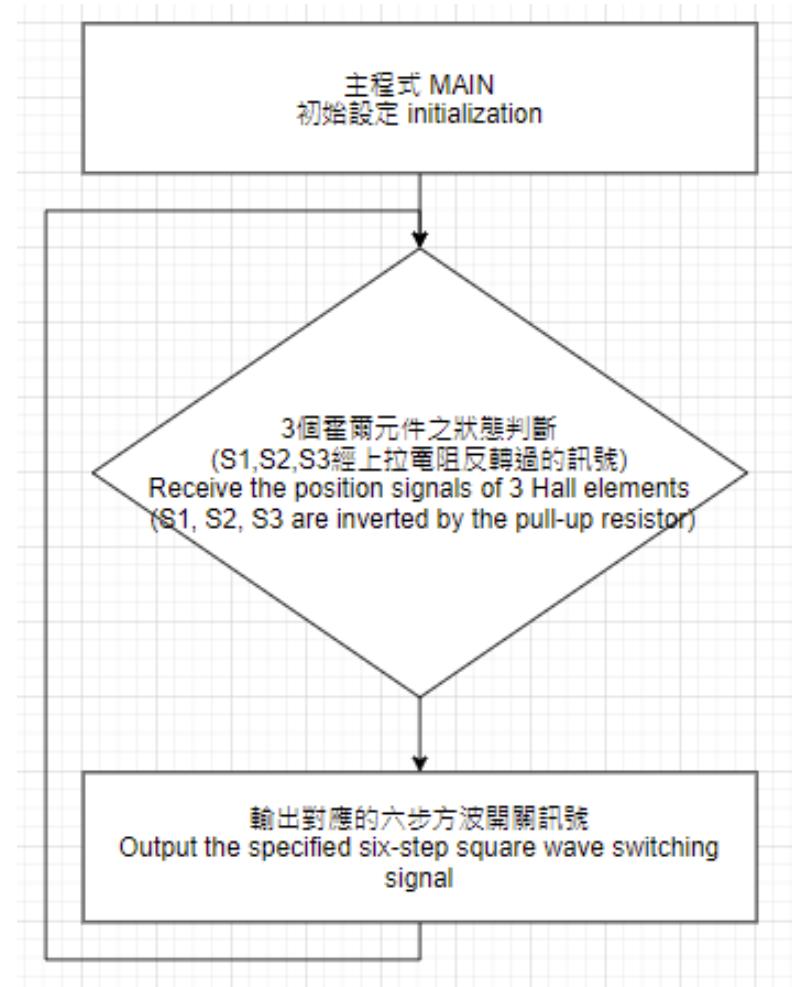


# Handout 6 Code

## SixStep

最基礎款

The most basic one



## Handout 6 Code

## Drive Table

接下來以一張隨機的破損驅動表，複習六步方波驅動法。

Next, use the random damage drive table to review the six-step square wave drive method.



U	V	W	S1	S2	S3
H	L	X			
H	X	L			

狀況很糟糕，接線資訊全滅，也沒有轉向資料，馬達上的霍爾IC還掉下來了。  
但是表中還留著兩筆資料跟一個先後標記。

The situation is very bad, the wiring information is completely gone, there is no steering data, and the Hall IC on the motor has fallen off. However, there are still two pieces of information and a sequential mark in the table.



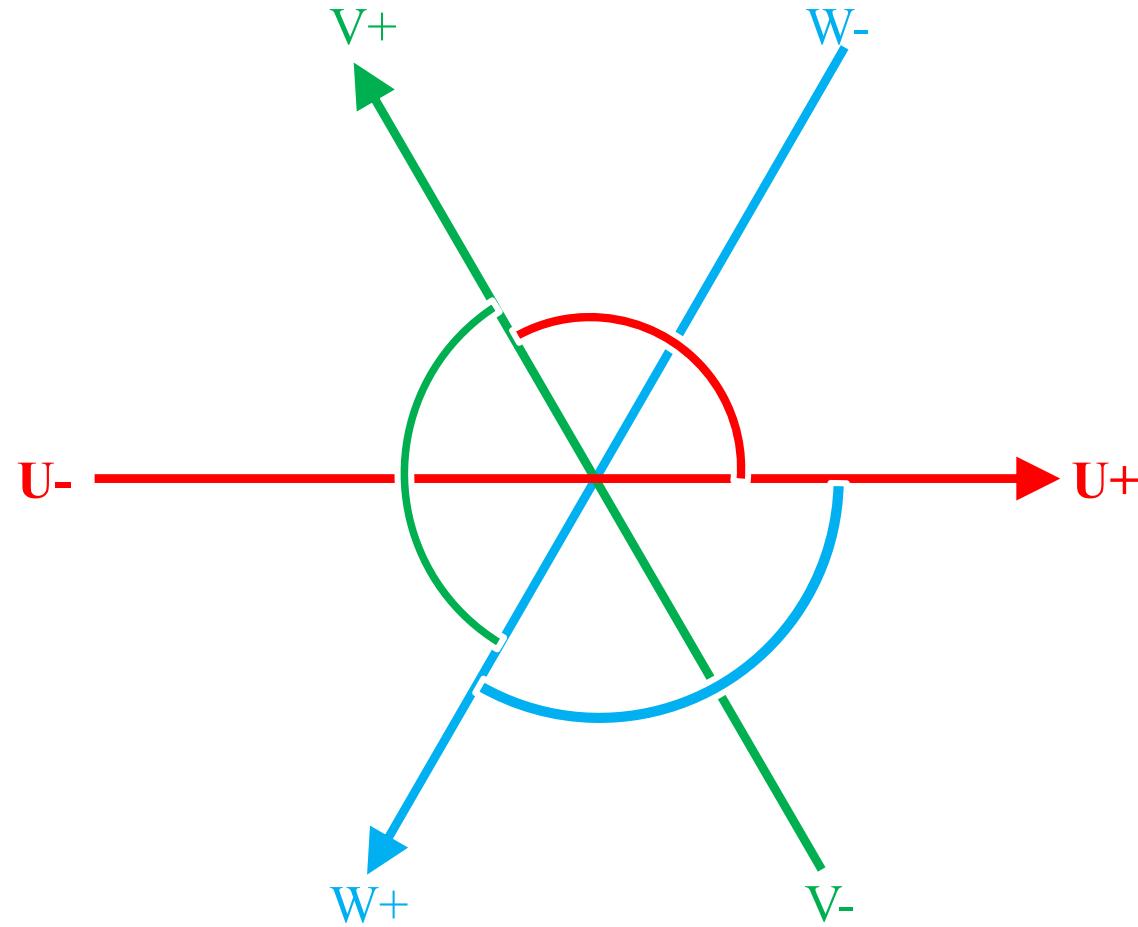
## Handout 6 Code

## Drive Table

表中可知至少是個三相馬達( $U, V, W$ )。第一步是假設一個座標系。

The table shows a three-phase motor ( $U, V, W$ ). The first step is to make a coordinate system.

設定H是向量的正方向 Set H to be the positive direction of the vector



$U$	$V$	$W$	
H	L	X	
H	X	L	

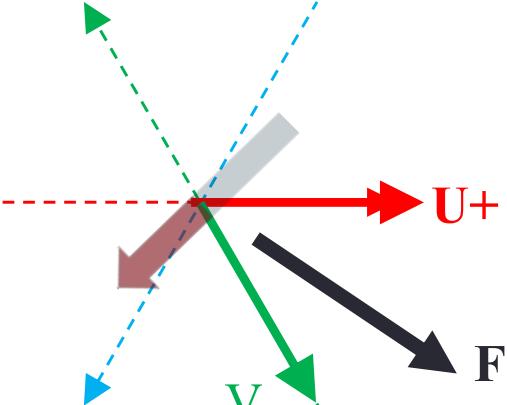
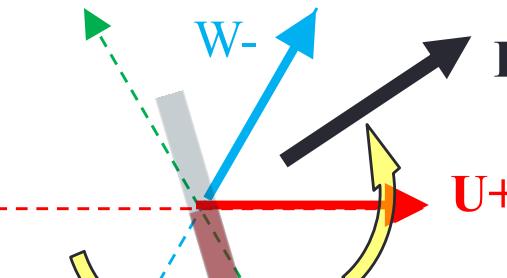


## Handout 6 Code

## Drive Table

加上假想的二極轉子

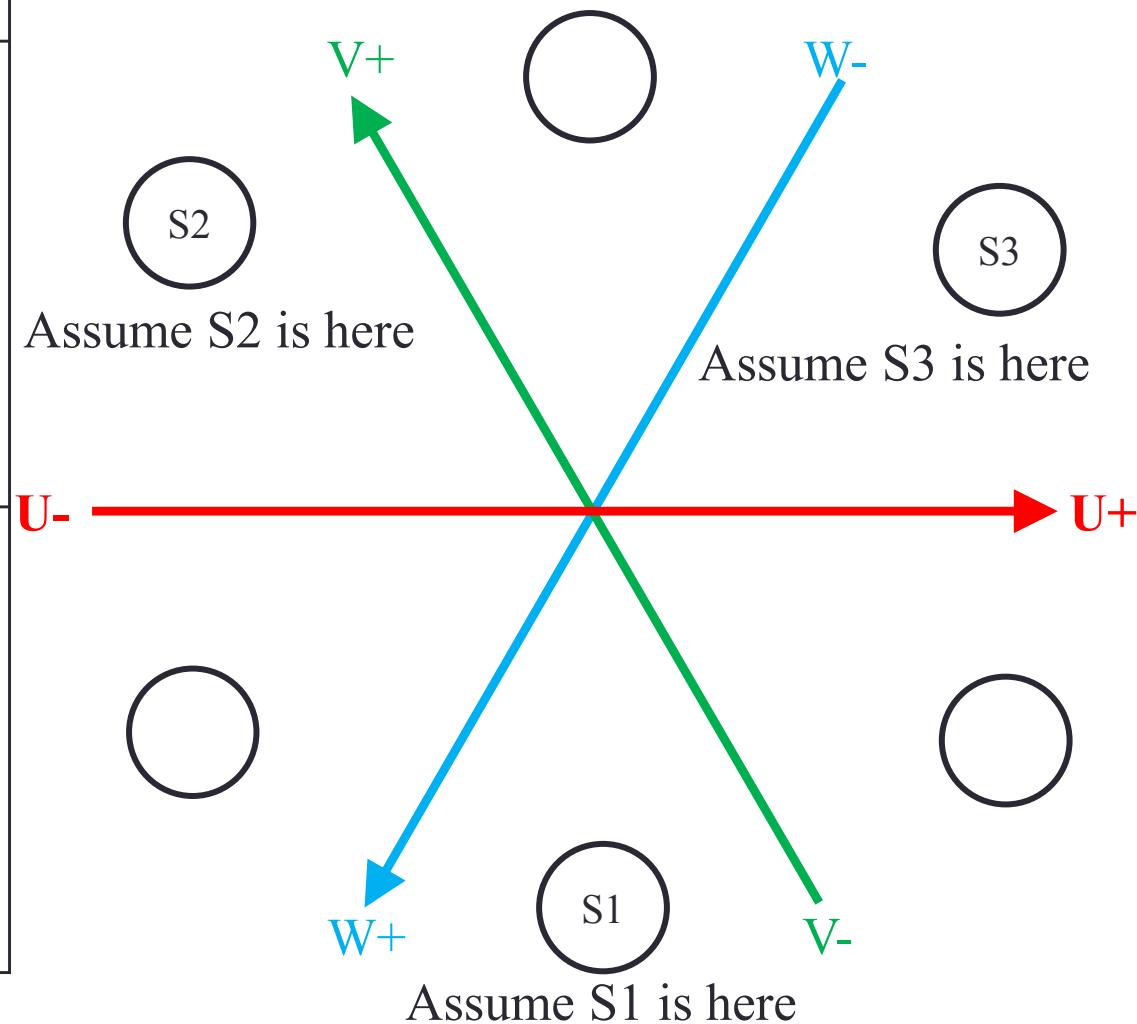
Add an imaginary two-pole rotor

<b>U</b>	<b>V</b>	<b>W</b>	
H	L	X	
H	X	L	

為產生轉矩，合力與轉子應接近正交  
For torque, the resultant force should be orthogonal to rotor

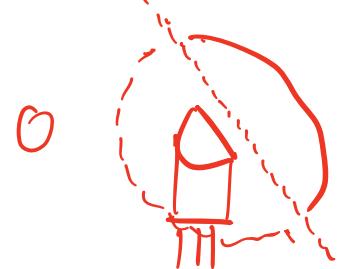
接著要決定霍爾IC安裝的位置

Next, decide where to install the Hall IC



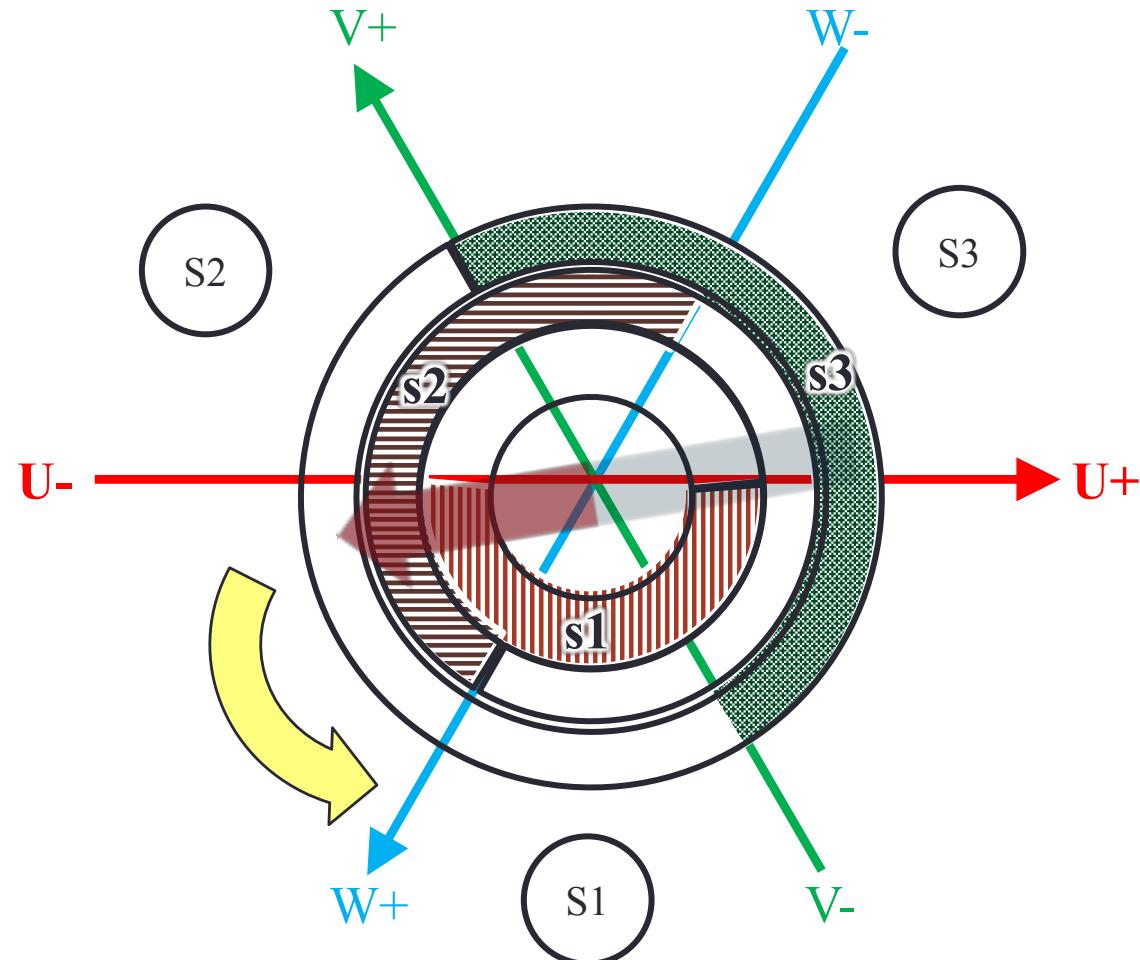
## Handout 6 Code

## Drive Table



實驗可知此霍爾元件以磁通N為1，S為0，且判斷的角度範圍約是180度電氣角。

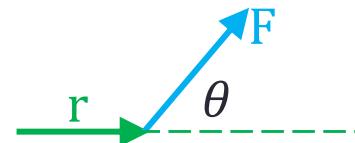
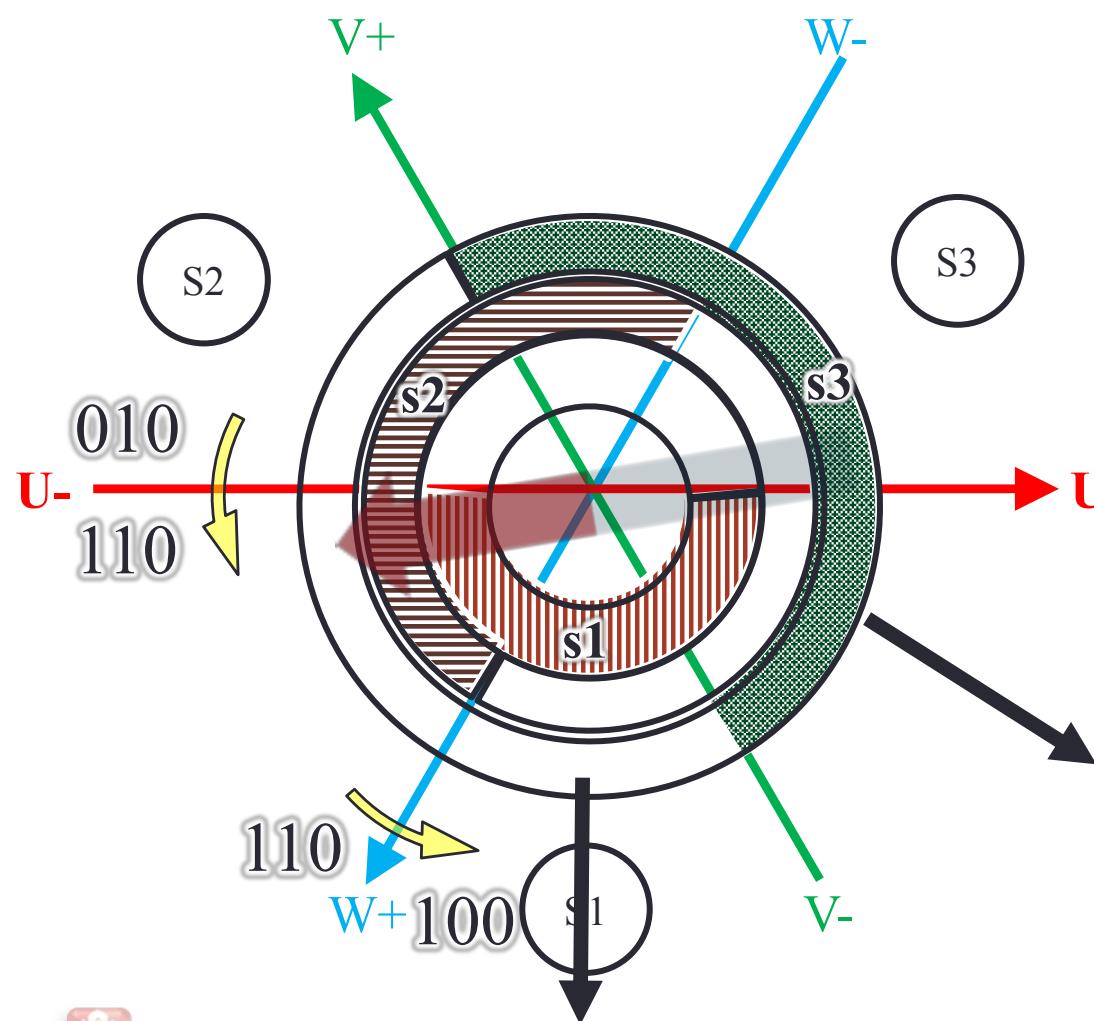
Experiments show that the Hall element uses a magnetic flux N of 1, and S of 0, and the sensor range is about 180 degrees in electrical angle.



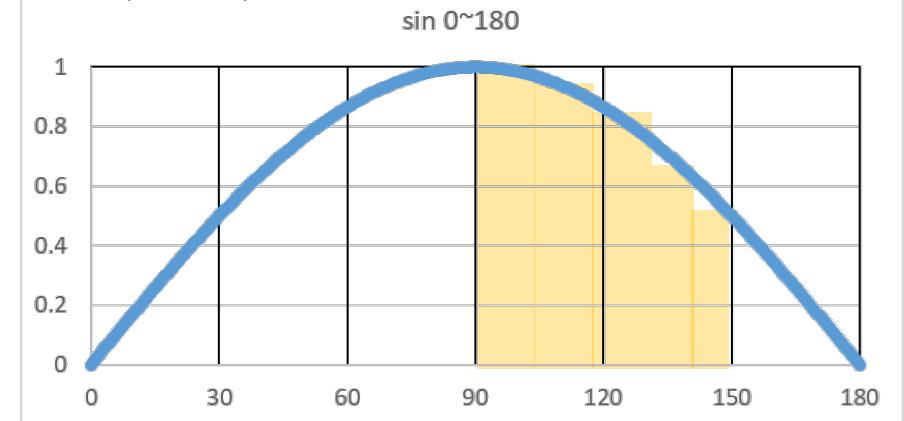
# Handout 6 Code

# Drive Table

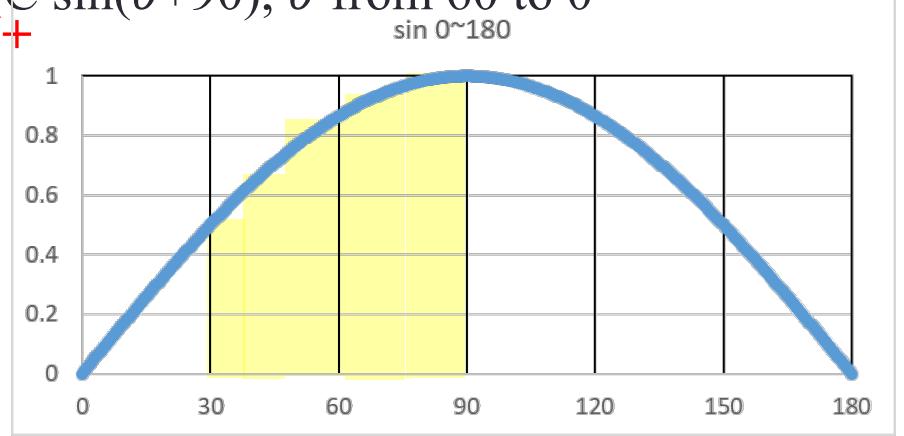
110, CCW for example:



$\tau(\text{轉矩}) = r(\text{力臂})F(\text{力量})\sin \theta$   
進入110時( $180^\circ$ )有利合力是 $W+V-$   
 $C \sin(\theta+30)$ ,  $\theta$  from 60 to 0



離開時( $240^\circ$ )的則是 $U+V-$   
 $C \sin(\theta+90)$ ,  $\theta$  from 60 to 0



轉矩不佳 Torque output is bad  
>調整霍爾元件位置 change Hall position

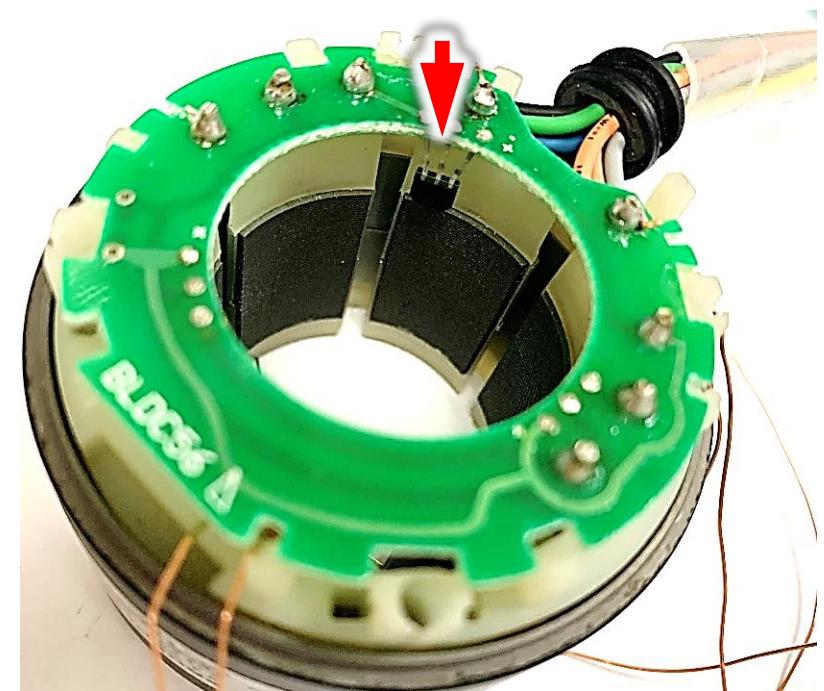
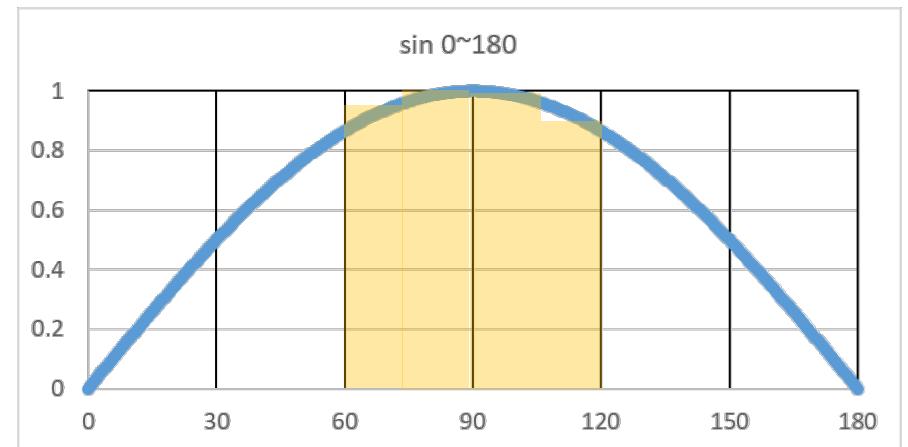
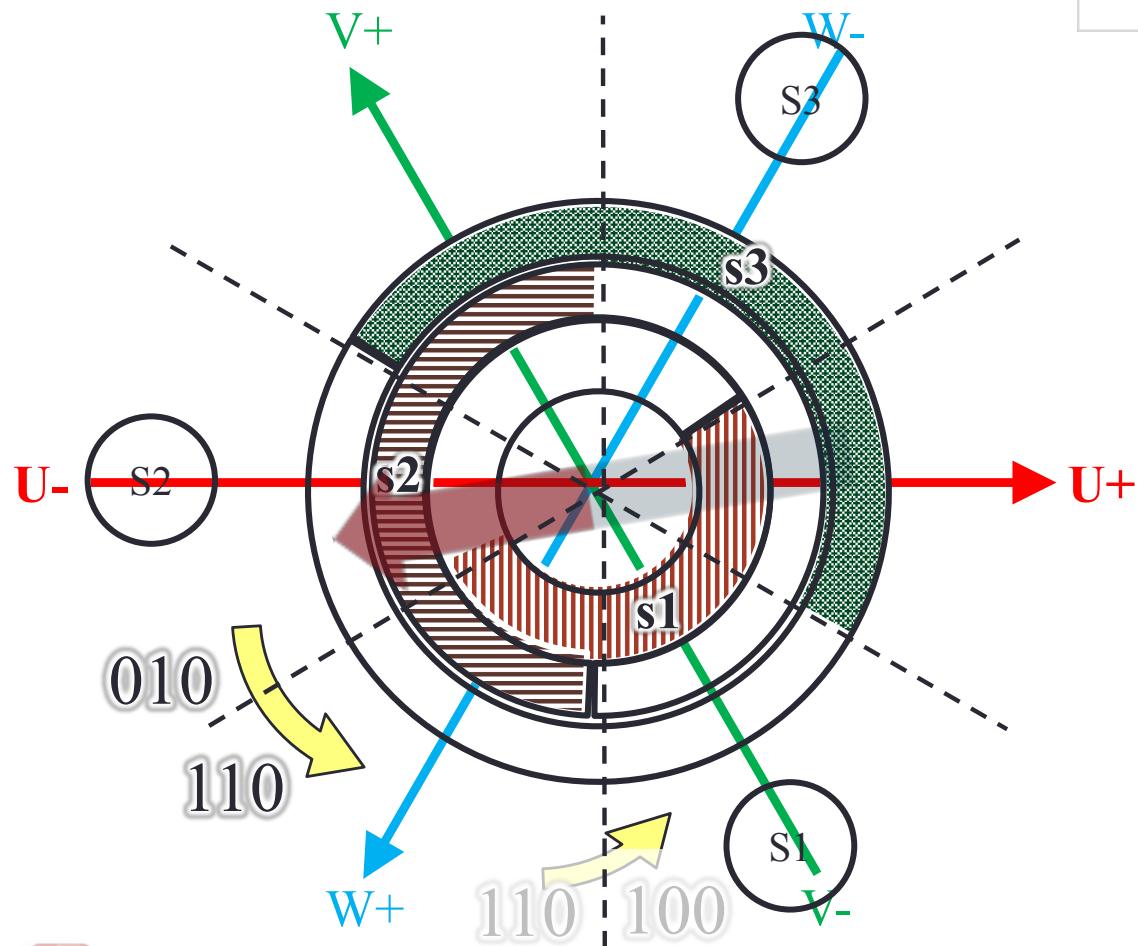


# Handout 6 Code

# Drive Table

$C \sin(\theta+60)$ ,  $\theta$  from 60 to 0

新霍爾元件位置 new Hall position :



# Handout 6 Code

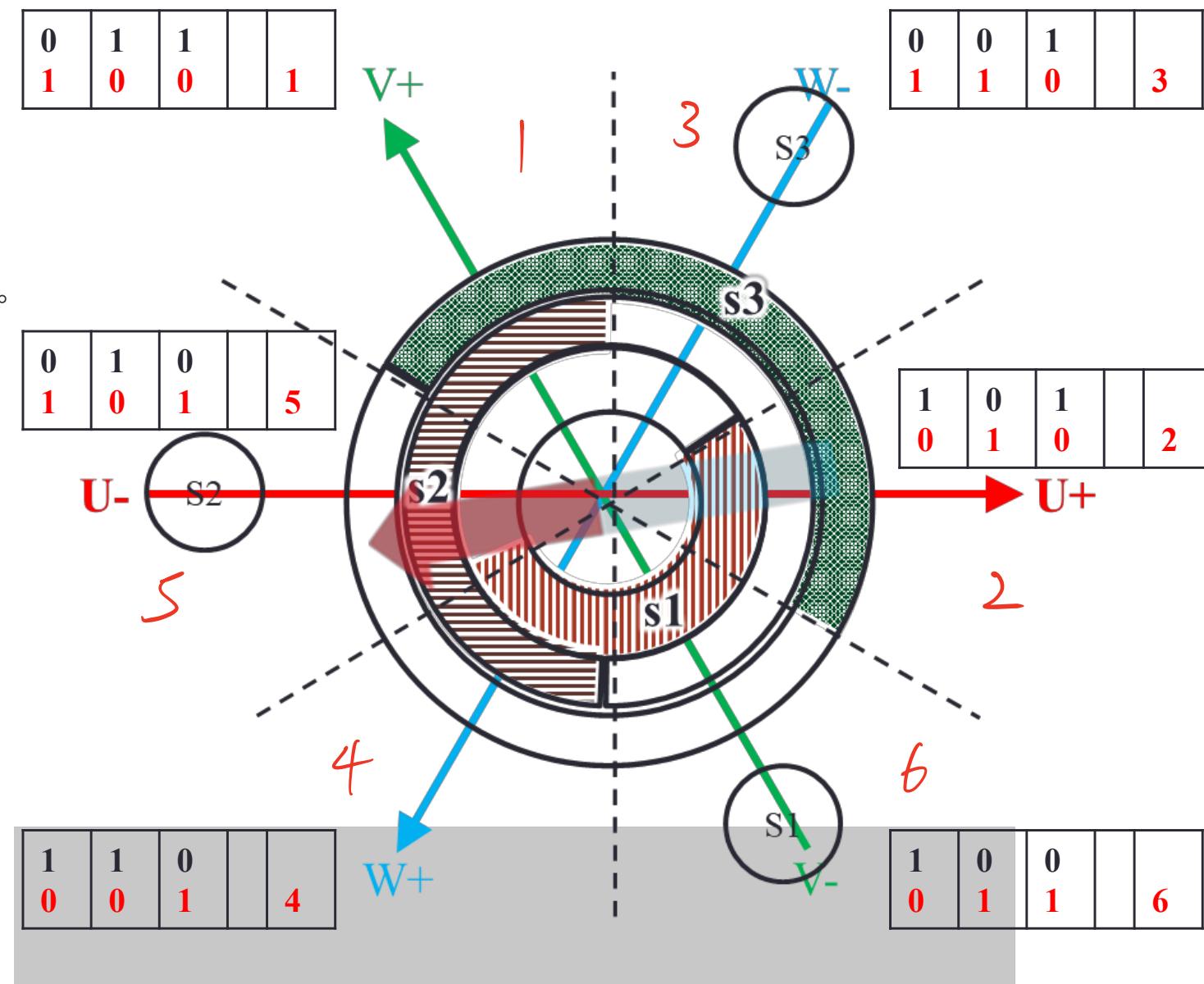
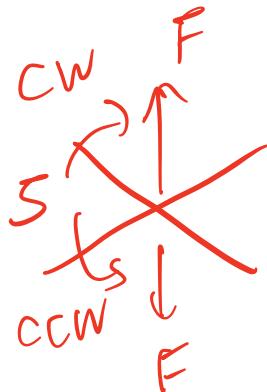
## Drive Table

S1	S2	S3		$S1*2^0+S2*2^1+S3*2^2$
----	----	----	--	------------------------

完成調整霍爾元件後，  
以二進制為扇區編號。

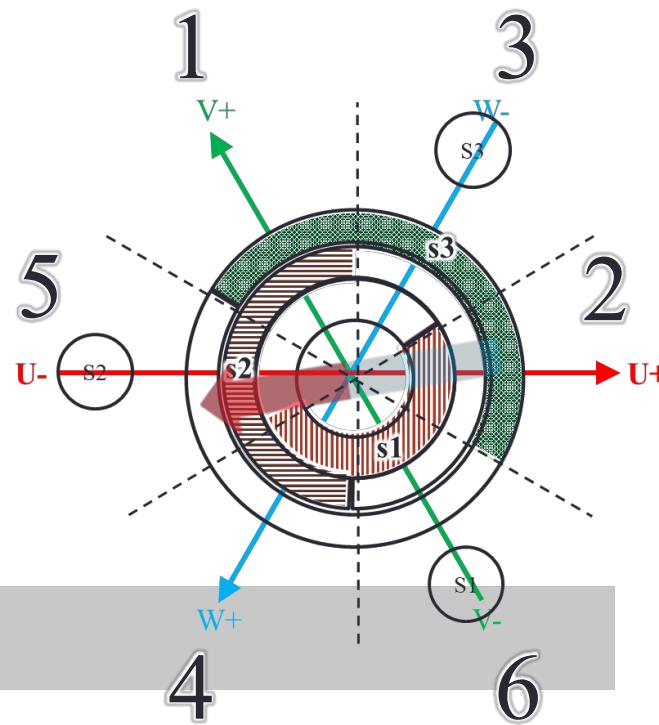
別忘記DSP讀取的是  
上拉電阻**反向**過的訊號。

Remember that there are  
pull-up resistors, so DSP  
will read **inverted signal**



## Handout 6 Code

## Drive Table



	U	V	W	S 1	S 2	S 3	
4	H	L	X	1 0	1 0	0 1	
6	H	X	L	1 0	0 1	0 1	
2	X	H	L	1 0	0 1	1 0	
3	L	H	X	0 1	0 1	1 0	
1	L	X	H	0 1	1 0	1 0	
5	X	L	H	0 1	1 0	0 1	

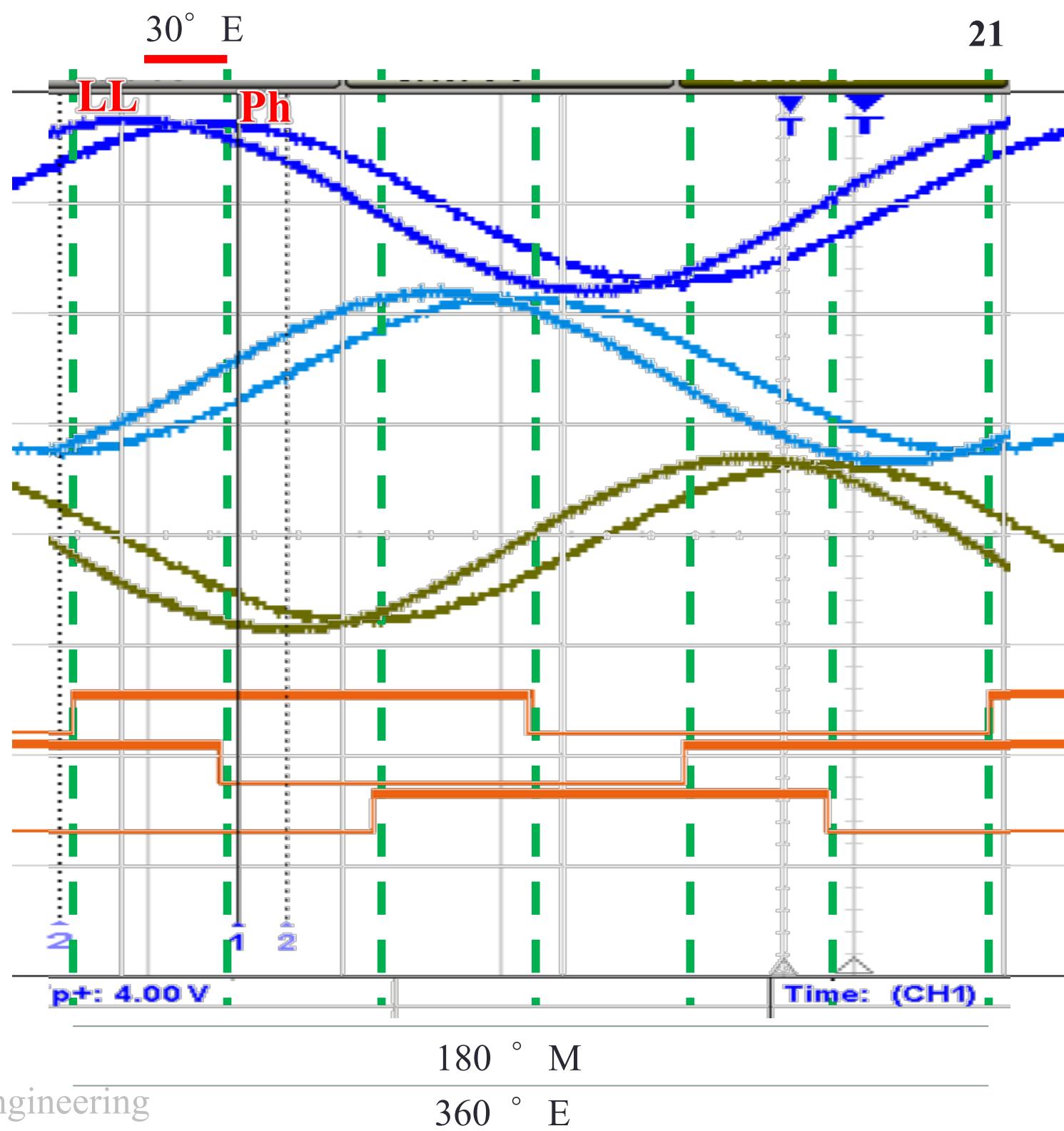


## Handout 6 Code

CCW

LL &amp; Ph

shift 30E



## Handout 6 Code

## Drive Table

練習：

對照實驗結果，嘗試找出測試時的馬達結構。

寫出帶有線色的完整驅動表。

嘗試推導反向旋轉時的驅動表。

Practice :

Comparing the experimental results, try to find out the motor structure.

Write a complete drive table with wire colors.

Try to derive a driving table for another steering.



# Handout 6 Homework / Midterm

請寫一個六步方波動程式。歡迎加入其他功能。

基本題：

從軸看向馬達，逆時鐘旋轉。需旋轉平順，無死點，可以從任何位置啟動。

嘗試部分：

嘗試增加驅動和控制功能。

測試方式：

於moodle預約時間，來B1的92x19進行實測實驗。

作業繳交方式：

一份壓縮檔，命名為HW7\_mid\_學號\_姓名，包含以下資料：

- 1 匯出的完整程式資料夾。
- 2 一份PPT/word使用流程圖說明程式，設計的功能或遇到的困難。
- 3 一個短影片展示程式的功能。



# Handout 6 Homework / Midterm

Please write a six-step square wave program. Other functions can be add in.

Basic :

Looking at the motor from the shaft, it rotates counterclockwise. The motor needs to rotate smoothly, without dead spots, and can be started from any position.

Challenge :

Try to increase drive and control functions.

Test method :

Schedule time in moodle and come to the lab92x19, B1 to do experiments.

Homework format :

A compressed file named **HW7\_mid\_ student No.\_name**, containing the following information:

- 1 The exported complete program folder.
- 2 A PPT/word use flow chart to illustrate the program, design functions or difficulties encountered.
- 3 A short video to demonstrate the functions of the program.

