User guide of watermeter DEMO

1. Structure of the watermeter DEMO

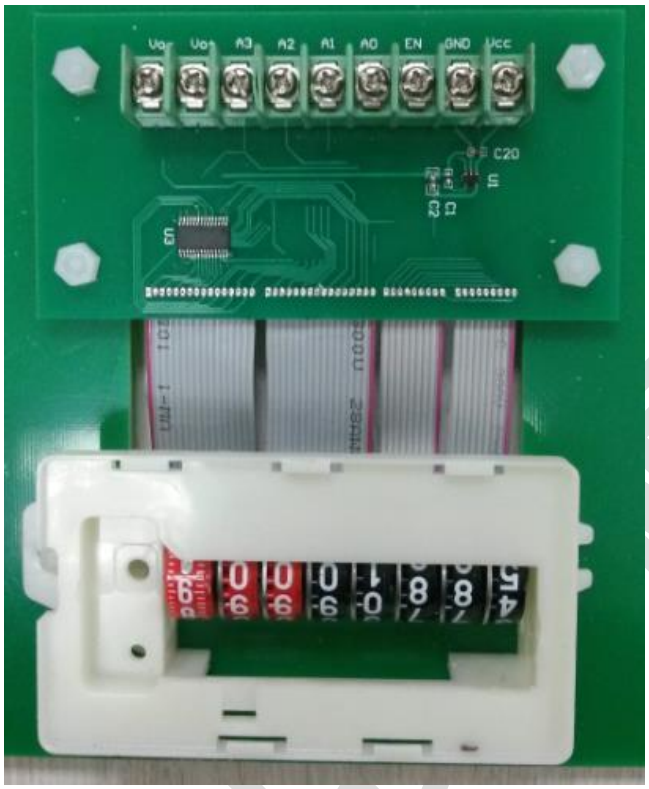


Fig1 picture of watermeter DEMO

Within the white housing, there are sensors sensitive to the magnet in the printed wheel. Sensors' signal output via terminals Vo- and Vo+ on the PCB at the right side.

Fig2 terminals of watermeter DEMO

2. Power supply of the DEMO

Vcc: 2.6~16V

Enable: 1.6~Vcc, disable: 0~0.55V

Bus voltage of the watermeter is 2.5 volts powered by a LDO connecting seriously to the Vcc. 2 batteries can be the power source of the watermeter DEMO.

If Enable pin is not used, it should tied to Vcc.

3. Selecting pins

A0, A1, A2, A3 are the selecting logic input pins, with high state voltage of 2.5V and low state voltage of 0. There are 16 sensors locate as below figure detecting the 8 wheels, in which X1, X2,…,X8 are sensing X-axis field component and Y1,Y2,…,Y8 sensing Y-axis field component. A MUX is used to determine which sensor works at a single time. Truth table is as below, wherein differential output can be monitored by terminals Vo- and Vo+:

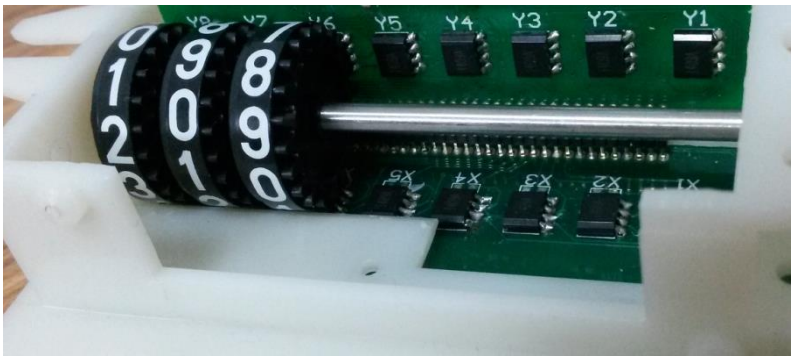


Fig3 X-sensor and Y sensor are assembled perpendicularly

Table 1 truth table of the system

A3	A2	A1	A0	selected sensor (differential voltage output)
0	0	0	0	X1
0	0	0	1	Y1
0	0	1	0	X2
0	0	1	1	Y2
0	1	0	0	X3
0	1	0	1	Y3
0	1	1	0	X4
0	1	1	1	Y4
1	0	0	0	X5
1	0	0	1	Y5
1	0	1	0	X6
1	0	1	1	Y6
1	1	0	0	X7
1	1	0	1	Y7
1	1	1	0	X8
1	1	1	1	Y8

4. Calculation of printed number of wheel

For a 8-wheels meter with 10 numbers on each wheel, there are 100000000 different possibilities of number, they are 0000001, 00000002, … ,99999999. It takes huge of time to rotate and test every number possibility for every different design. So Worst case measurement is taken.

Worst case happens when one wheels is being measured while other 7 wheels are aligned such that magnetic moment of the other magnet in said other 7 wheels are pointing to the same direction which gives biggest influence to the wheel being tested. If the system works in the worst case, it works in all 100000000 possibilities.

There are 10 small black points near each red number 0~9 which represent the 10 numbers of the print wheel. Thus, there are 100 worst case test points in each print number, meaning 800 worst case test points in 8 print wheels totally. Below shows the 100 worst cases on print wheel #1.

Table 2 100 worst cases on print wheel #1

Number of print wheel #1	Number of other 7 print wheels			
0	0000000	1111111	…	9999999
1	0000000	1111111	…	9999999
…	…	…	…	…
9	0000000	1111111	…	9999999

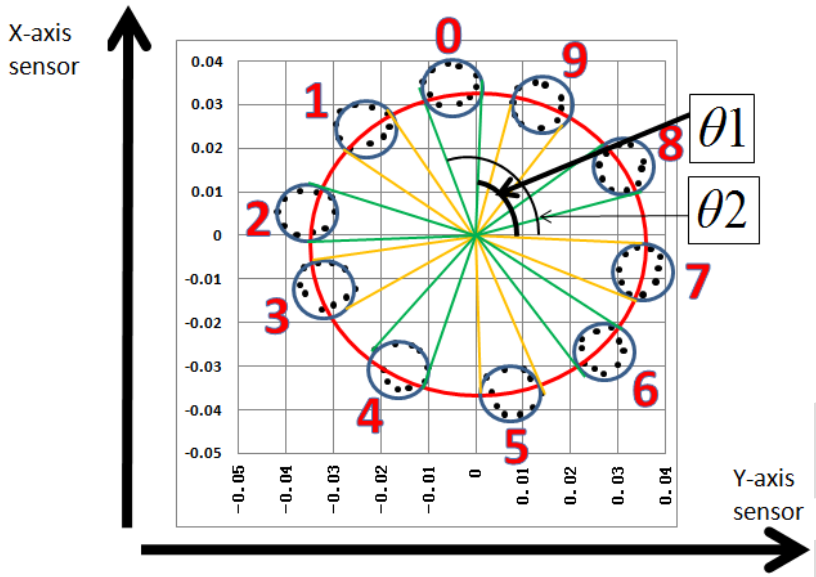


Fig 4 worst case result of print wheel #1

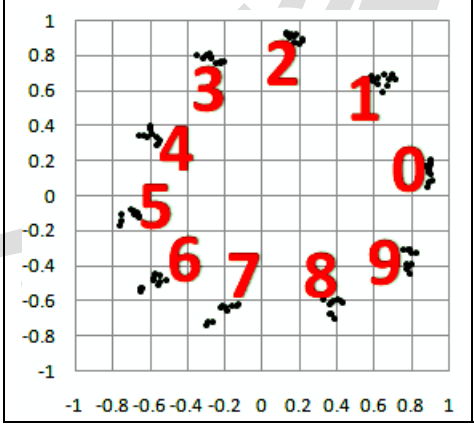
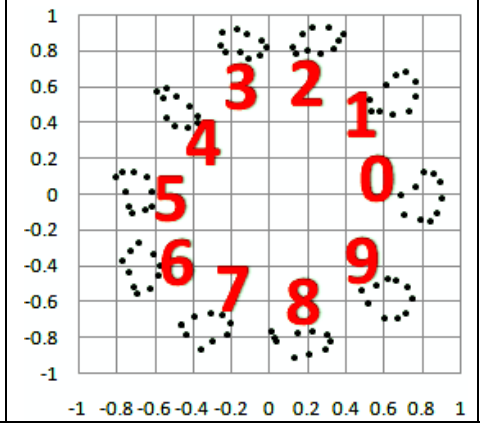
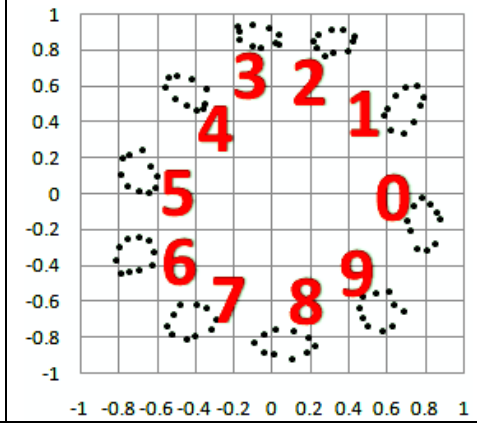
Worst case testing result of a printed wheel shows in Fig 4 in which the 2 vertically assembled sensor (we call them as Y-axis sensor and X-axis sensor) testing result is plot. Within the blue circle near red number 0, there are 10 small black points represent 10 worst cases while print wheel #1 is fixed in NUMBER 0 respectively. Be calculated by arc-tangent function, the angle of number 0 is between θ 1 and θ 2. For print number 0 of this wheel, calculated angle possibilities other than the 10 worst case should within the blue circle, which means angle should be between θ 1 and θ 2. The most important parameter of watermeter is neighboring interference which could be represented by the overlap of blue circle in above figure. We can see easily that in the above figure, there is no overlap between all neighboring blue circles, which means we can easily tell the number of the print wheel.

5. Testing data

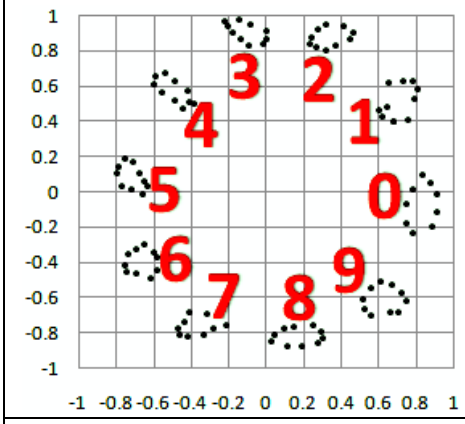
Testing data of all 8 wheels are shown in table 3, no overlap can be found. It means through calculation, the printed number of each wheel could be read.

In order to reduce calculation complexity, sensor with low offset should be used.

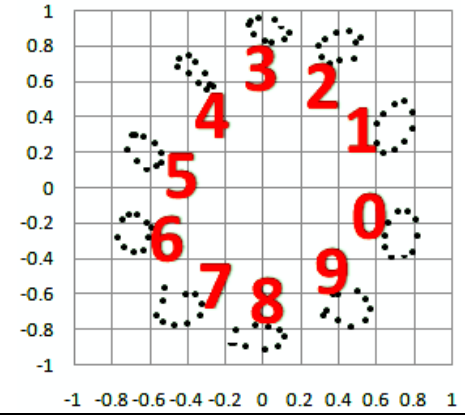
Table 3 worst case data of the watermeter DEMO

Wheel 1	Wheel 2	Wheel 3
		

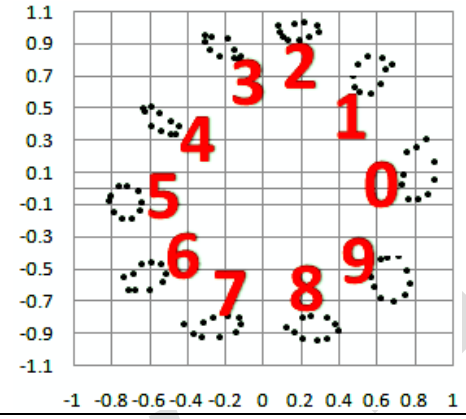
Wheel 4



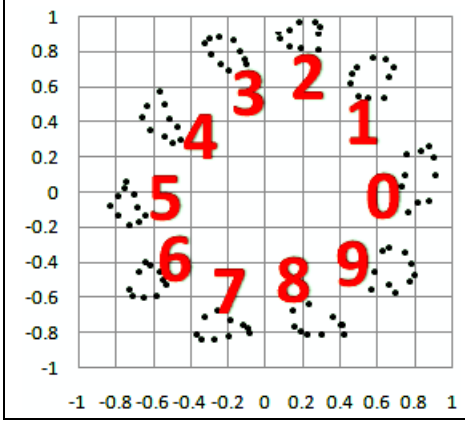
Wheel 5



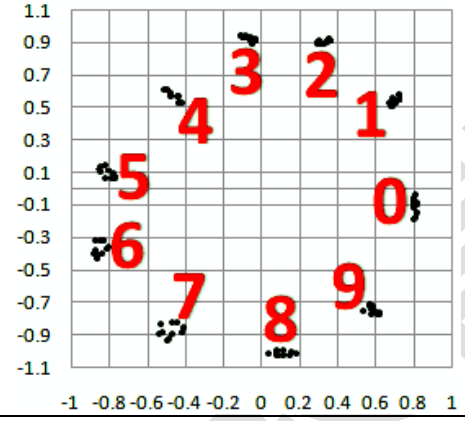
Wheel 6



Wheel 7



Wheel 8



6. note

A).The value of output capacitors connected between Vo+/GND and Vo-/GND should be no greater than 0.1uF. A higher value of these capacitors would severely degrade readout speed of the metering device.

B). The decoder (74HC238) is optional. It is used to reduce the current of the device by limiting the number of sensors that are simultaneously powered during the read cycle. Removing this component can slighlty reduce system cost, but removing it increases the supply current by about 20uA during the read cycle. If the decoder is not used, the Vcc pins of all TMR sensors should be connected in parallel between the output terminal of LDO and GND.

C). The position of the sensors, permanent magnets, and the PCBs in this DEMO is not controlled to highest practically achievable accuracy that could result from mass production. The data in this testing report threfore does not show the best possible performance of this metering concept.

演示板使用说明

1. 水表演示板总体结构

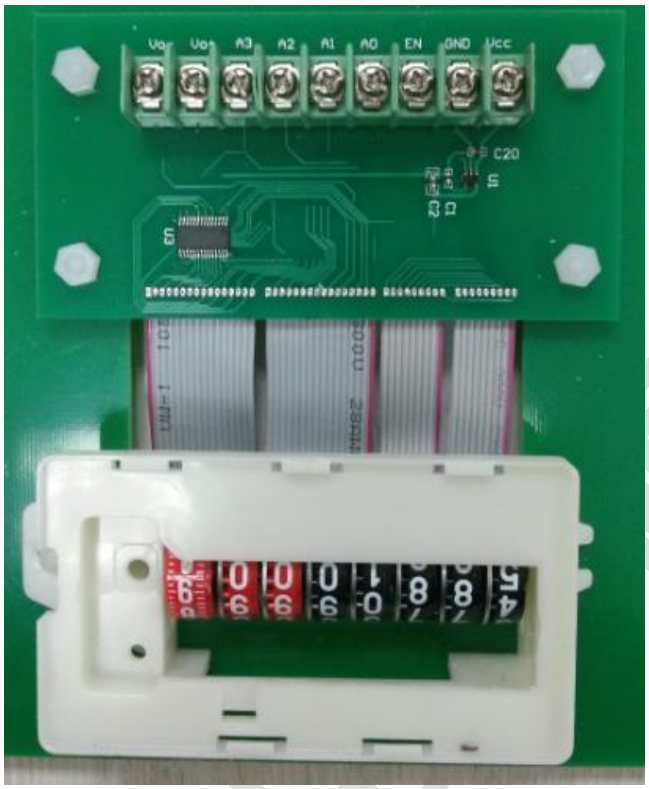


图 1 水表演示板实物

在白色的水表外壳内部，安装有 8 个字轮，字轮内部有磁铁，磁铁附近有磁场传感器，用于感应磁铁的磁场强度和方向。磁场传感器输出端为 PCB 上的 Vo-端和 Vo+端。

图 2 水表演示板的电气接线端

2. 演示板电源

Vcc 端: 2.6~16V

Enable 电压: 1.6~Vcc, disable 电压: 0~0.55V

在 Vcc 端之后，有一个 LDO 为演示板中所有元件供电，该 LDO 输出电压为 2.5V。可采用两节 5 号或者 7 号电池作为演示板的能量来源。

若不使用 Enable 端，则 Enable 端必须与 Vcc 端短路连接.

3. 传感器通道选择

A0，A1，A2，A3 为演示板的传感器通道选择端。演示板中有 8 个字轮，每个字轮都需要两个磁场传感器来检测其磁场，第一个字轮对应的传感器为 X1，Y1，第二个为 X2，Y2，。。。，以此类推。所有 X 传感器平行排列，所有 Y 传感器平行排列。X 传感器和 Y 传感器垂直放置，检测相互垂直的磁场。 多路复用器件的 A0，A1，A2，A3 输出信号可以作为 16 个传感器的选择信号。表 1 为演示板的真值表，其中被选择的传感器输出为差分信号 Vo-和 Vo+。

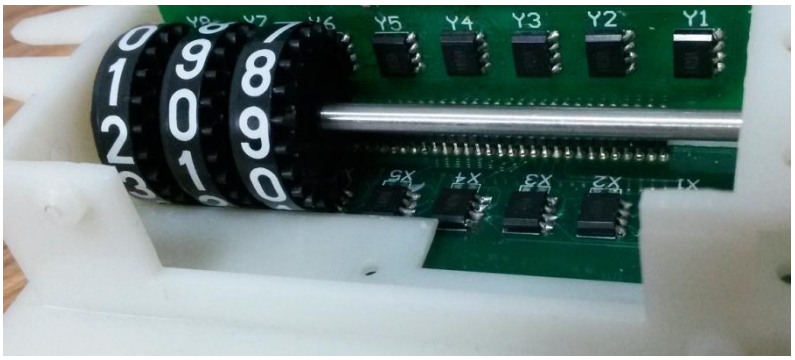


图 3 X 传感器和 Y 传感器垂直放置

表 1 水表演示板真值表

A3	A2	A1	A0	被选传感器（输出为差分输出）
0	0	0	0	X1
0	0	0	1	Y1
0	0	1	0	X2
0	0	1	1	Y2
0	1	0	0	X3
0	1	0	1	Y3
0	1	1	0	X4
0	1	1	1	Y4
1	0	0	0	X5
1	0	0	1	Y5
1	0	1	0	X6
1	0	1	1	Y6
1	1	0	0	X7
1	1	0	1	Y7
1	1	1	0	X8
1	1	1	1	Y8

4. 字轮数字的计算方法

由于演示板中字轮有八个，每个字轮的数字有 0，1，。。。，9 这十种可能，那么八个字轮数字的组合可能性有 100000000 种。在评估该演示板性能时，用到了“最差情况测量法”，若最差情况下，水表能准确判定对应的数字，那么对于所有的情况，该水表能准确判定字轮的数字。下面详细描述该测量方法。

以其中第一个字轮为例，当其他七个字轮排列方向一样，即字轮中磁铁磁化方向一样时，对字轮 1 的影响最大。对第一个字轮的数字 0，需要测试 10 个点，为其他 7 个字轮同时为 0，1，2，。。。，9；对第一个字轮的数字 1，也需要测试 10 个点，为其他 7 个字轮同时为 0，1，2，。。。，9；于是，对第一个字轮的 0，1，。。。，9 十个数字，需要测试 100 个点。对八个字轮的测试，需要 800 个测试点。

表 2 第一个字轮的 100 个“最差情况”测试点

第一个字轮的数字	其他 7 个字轮的数字			
0	0000000	1111111	…	9999999
1	0000000	1111111	…	9999999
…	…	…	…	…
9	0000000	1111111	…	9999999

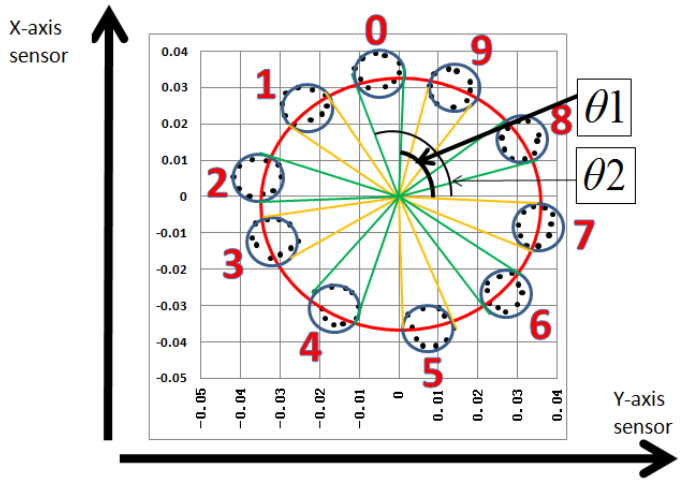


图 4 最差情况测试结果示例

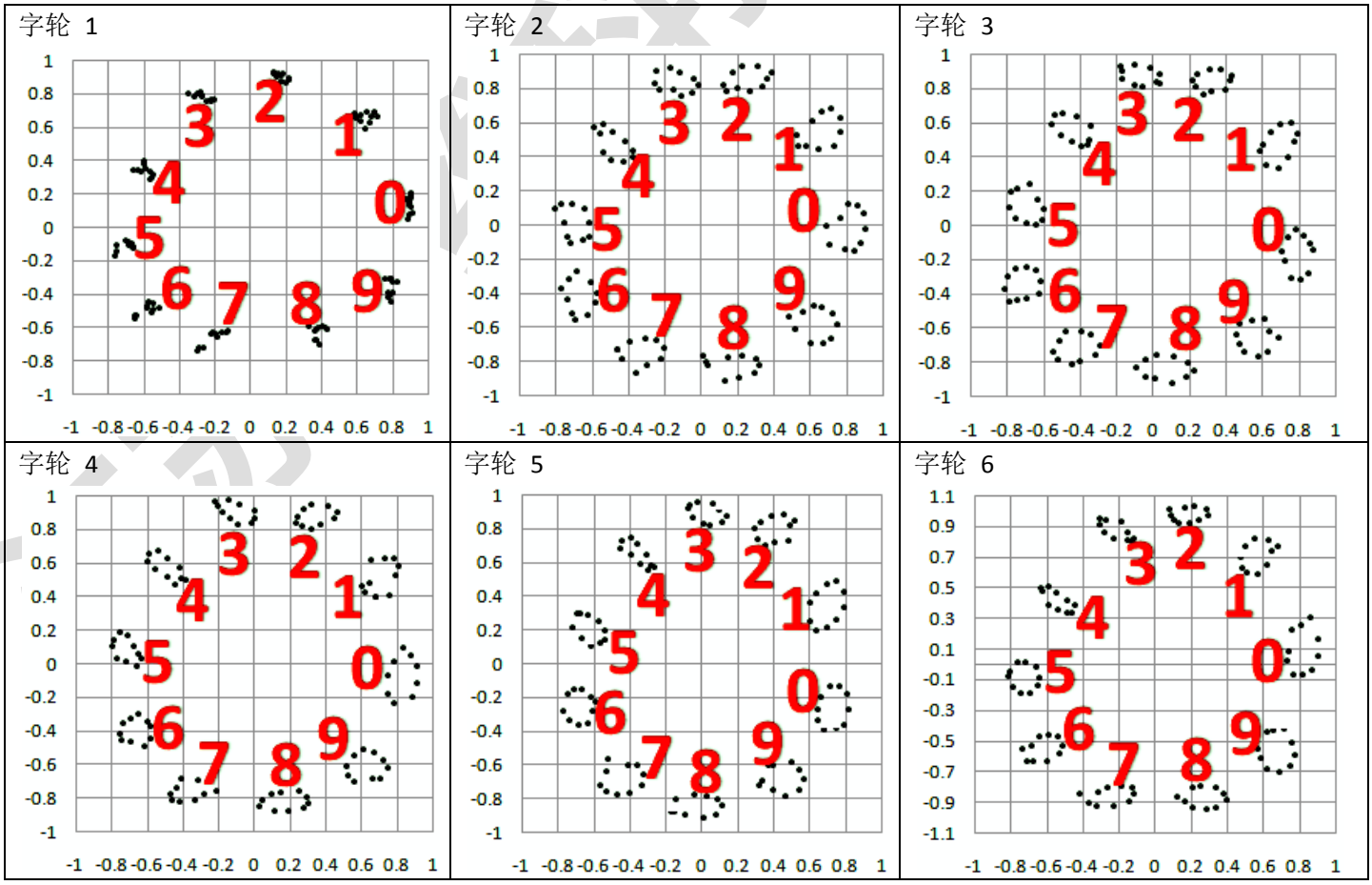
图 4 是测试结果的示例，将每个字轮对应的传感器命名为 X-asix 传感器和 Y-axis 传感器，两个传感器垂直安装。在红色的数字“0”旁边的蓝色圆圈中，10 个点代表该字轮数字为 0 时的 10 个最差情况。利用反三角函数，字轮“0”的最差情况下，对应的计算处理出来的角度介于 θ 1 和 θ 2 之间。对于该字轮的其他情况，对应计算出来的角度也应介于 θ 1 和 θ 2 之间。对于本直读式水表，必须考虑到相邻字轮之间的互相影响。从上图中数字 0，1，。。。9 对应的蓝色圆圈是否有重叠，可以判断该字轮有没有出现读数重叠的情况（图中没有重叠）。

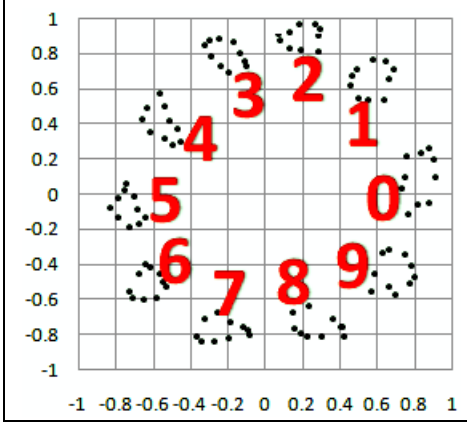
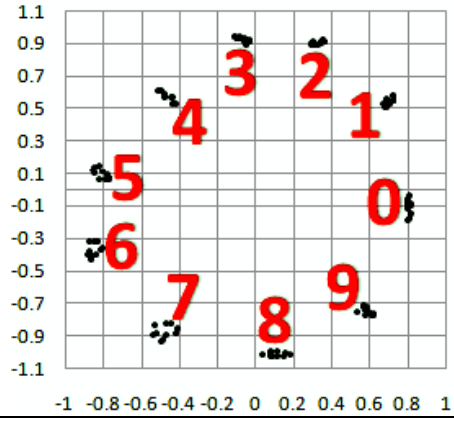
5. 测试数据

下表是八个字轮的测试数据，从表中可以看出，所有字轮均没有出现字轮数字重叠的情况，表明：经过反三角函数计算后，所有字轮的数字可以计算出来。

在选择传感器芯片时，注意尽量选择 Offset 小的芯片，以减小计算复杂度。

表 3 八个字轮的“最差情况”测试数据



字轮 7	字轮 8	
		

6. 备注

A). 演示板输出端 Vo+和 GND 之间电容会影响数据读取速度，推荐小于 0.1uF。Vo-和 GND 之间电容同理；

B). 演示板中的译码器 74HC238 是可选器件，使用该器件时，可以使系统的电流消耗降低 20uA；若从成本的角度考虑，不使用该器件，则需要将所有传感器的 Vcc 端连接到 LDO 的输出端；

C). 该演示板在装配时存在位置的偏移，测试时字轮的位置也存在偏差，因此本演示板的输出不代表用此方法构建的仪表的最佳输出。在实际应用中，应控制传感器、磁铁、线路板的安装精度，以达到最佳的效果。