ZhiSENSOR

Xi'an ZhiSENSOR Technologies Co., Ltd.

P1100 MEMS Mirror Module

Data Sheet

V1.4

P1100 Data Sheet

The P1100 is a one-axis MEMS mirror module. This module consist of a MEMS mirror chip and closed-loop control circuit.

This module can provide real-time scanning position of MEMS mirror. The module outputs a marking signal when the MEMS mirror scanning a marking angle. Furthermore, the marking angle is configurable to users. Incremental pulse signals are indicated as the position of MEMS mirror with a maximum resolution of 0.05°.

Applications:

- **Solid-state LiDAR**
- **Industrial Inspection**

Features:

- **The maximum scan angle is 60°**
- **The highest angular resolution is 0.05°**
- **The resonant frequency is 5.8±10%KHz**
- **Mirror diameter 1.3mm**
- **Data interface SPI**
- **High reliability and stability**
- **Low power consumption, small size**

The following conditions must be strictly observed for proper application.

1. Explained specially

The core component of the P1100 is a MEMS mirror. Due to the principle limitation, the MEMS mirror cannot be kept at a fixed angle, and the operating frequency of the MEMS mirror cannot be adjusted.

2. Interface

This module uses df37b-10dp-04v as the connector, and the number of plugs is 20.

3. Protective glass

The quartz glass protects the MEMS mirror in the process of testing, storage, transportation and usage. The module can be used without the protective glass if the application environment meets requirements. The details are described in section 2.3.

4. Scan angle

Since this module is based on MEMS technology, due to the principle limitation, the maximum optical scan angle is 60°. The configurable scan angle of the module is divided into two types: Type A: 50°~ 60°； Type B: 55°~ 60°. If set scan angle less than the minimum scan angle (Type A: 50°，Type B: 55°), the scan angle cannot be changed.

5. Glossary

marking signal: Unless otherwise specified, it means the general name of the zero position marking pulse and the angle marking pulse;

zero position marking pulse: Electric pulse is given out by the TRIG0 pin when the MEMS mirror scans from negative position to positive position and passes through the zero position, and can be used to determine the start time of one scan period of the MEMS mirror;

angle marking pulse: Electric pulse is given out by the TRIG1 pin whenever the MEMS mirror scans a specific angle, and can be used to calculate the position of the MEMS mirror in real time;

range of angle marking pulse: It means that angle marking pulse output in this range. The unit is degree. For example, if the range of angle marking pulse is 40°, it means that there is angle marking pulse output within the scan angle of ±20°;

incremental angle of angle marking pulse: angle between two adjacent angle marking pulse.

Contents

1. Introduction

The most important component of P1100 is a MEMS mirror, which is a chip based on MEMS technology. Under the driver signal, the MEMS mirror makes a resonant torsional.

The P1100 output marking signal, which can be used to calculate the single of the MEMS mirror in real time, and the marking signal can be freely set by the user as needed.

After the P1100 started, the module gives the operator 5s for setting the scan angle and incremental angle of angle marking pulse. If the parameters of the module are successfully set, the marking signal will be output according to the setting. Otherwise, the system will automatically set by default parameters: the scan angle is 60°, the incremental angle of marking signal is 1°.

2. Features

2.1 Features of the MEMS Mirror

The P1100 is designed based on MEMS mirror. The MEMS mirror is made of monocrystalline silicon and has the characteristics of high reliability, small size, and lightweight. Aiming to increase reflectivity, the mirror is coated with Au.

The diameter of the MEMS mirror is 1.3mm and the resonant frequency is 5.8±10% kHz.

2.2 Electrical Features

2.2.1 Electrical Connection

The power supply and various signals of the P1100 must be connected through the connector. The schematic diagram of connector is shown in Figure 2-1, and the connector is DF37B-10DP-04V. It is recommend use the HRS connector DF37NB-10DS-04V when applying the P1100. The datasheet of this connector can be found in the official website of HRS (www.hirose.com).

Figure 2-1 shows the front side of the connector, and figure 1-2 shows the back side. Pin number of connector is marked in the figure. Furthermore, the length of the cable is approximately 176mm.

(a) Front side (b) Back side

Figure 2-1 Schematic diagram of the connect

The function of the pins as list in table 2-1.

Table 2-1 The function of the pins

Pin	Symbol	Input/Output	Function	Condition
1	NC	-	-	-
2	SPI_MISO	Output	Master Input Slave Output	LVTTL3.3
3	SPI_MOSI	Input	Master Output Slave Input	LVTTL3.3
4	SPI_SCK	Input	Serial Clock (Output from Master)	LVTTL3.3
5	SPI_CS	Input	Chip Selection	LVTTL3.3
6	VCC	-	Power supply	5V
7	GND	-	GND	GND
8	TRIG0	Output	zero position marking pulse	LVTTL3.3
9	TRIG1	Output	angle marking pulse	LVTTL3.3
10	NC	-	-	-

2.2.2 Electrical Requirements

Please abide by the requirements shown as below:

Table 2-2 Absolute Maximum Ratings

Symbol	Min	TYP	Max	Unit
VCC	-0.2	5.0	6.0	V
	-	-	300	mA
SPI_MISO	-0.3	3.3	5.0	V
	-	-	25	mA
SPI_MOSI	-0.3	3.3	5.0	V
	-	-	25	mA
SPI_SCK	-0.3	3.3	5.0	V
	-	-	25	mA
SPI_CS	-0.3	3.3	5.0	V
	-	-	25	mA
TRIG0	-0.5	3.3	3.75	V
	-	-	10	mA

TRIG1	-0.5	3.3	3.75	V
	-	-	10	mA

2.2.3 Voltage and Power Consumption

The P1100 should be operated under the required supply voltage (5v dc). Table 2-3 shows the supply voltage and power consumption of P1100.

Table 2-3. Voltage and power consumption

Items	Conditions	Min	TYP	Max	Unit
Supply voltage	-	4.8	5.0	5.2	V
Power consumption	Operating	80	88	103	mA
	Shutdown	67	70	73	mA

2.3 Environmental Features

The working environment requirements of P1100 are shown in table 2-4.

Table 2-4. The environment requirements of P1100

Items	Protective Glass	Conditions
Working temperature	With Glass	-10℃ to +50℃
Storage temperature		-40℃ to +85℃
Working temperature	Without Glass	-10℃ to +50℃
Storage temperature		-40℃ to +85℃
Working humidity		<65 %RH
Storage humidity		<65 %RH
Working particle concentration		Level 10000 or higher according to GB/T16292-2010
Storage particle concentration		Level 10000 or higher according to GB/T16292-2010

Note: The quartz glass will protect the P1100 in the process of testing, storage, transportation and during the usage. In addition, the P1100 can only be applied without the protective glass if the application environment meets requirements.

2.4 Material Properties

The material components of the P1100 are the aluminum shell, ceramic PCB and a quartz protective glass. The total weight is 8g.

2.5 Working Items

2.5.1 Start Time

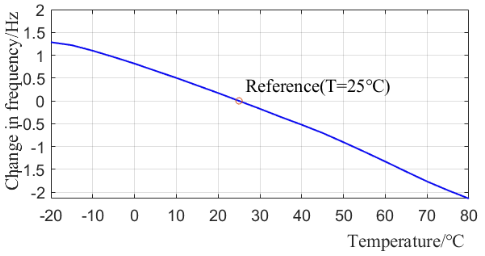
(1) Start time (after power on): <20s

2.5.2 Precision

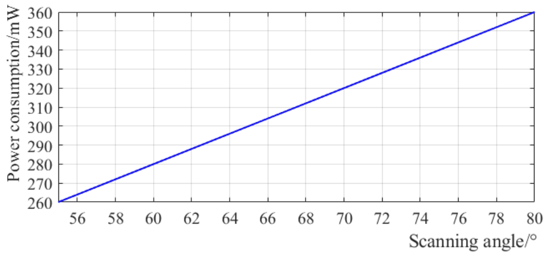
(1) Scan angle error: < 0.05 °

(2) The maximum marking angle: 0.05°

2.5.3 Typical Characteristics



2-2 Relationship between change in frequency and temperature



2-3 Relationship between scan angle and power consumption

3. Application Specification

3.1 Parameter configuration

3.1.1 Protocol of communication

P1100 communicates with external devices through SPI to configure parameters and query status. Figure 3-1 shows how the P1100 works in slave mode and connects to the SPI master.

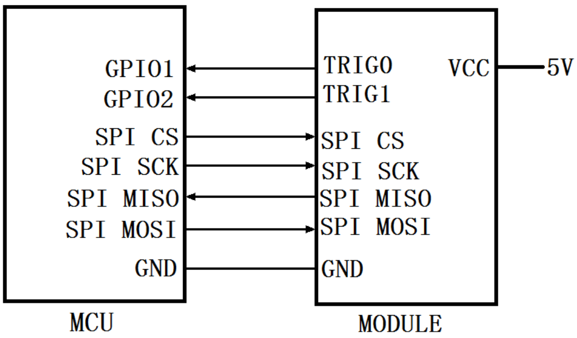


Figure3-1 the connection between P1130 and SPI master

Figure 3-2 shows that, the data are sampled along with the rising edge of the clock line. The data length is 16bits.

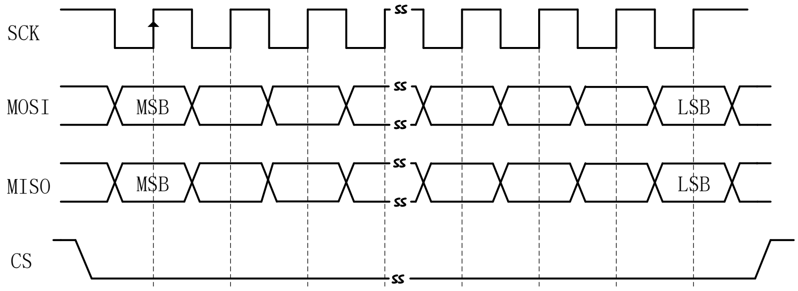


Figure 3-2 Sequence Diagram

3.1.2 Configure Parameters

Users can configure the P1100 according to a certain format, which are shown in table 3-1.

Table 3-1. Data format

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	0	scan angle													
1	0	incremental angle of angle marking pulse													
0	0	range of angle marking pulse													

According to the type of P1100 (A/B type), the configurable range is different. The configurable range of type A is 50°~60°, and the configurable range of type B is 55°~60°. When the scan angle is configured less than 50° for the A-type or 55° for the B-type, the scan angle of the P1100 will be maintained at 50° for the A-type or 55° for the B-type.

The minimum incremental angle of angle marking pulse is 0.05°, and it must be ensured that the incremental angle of angle marking pulse to be configured is an integral multiple of 0.05°, and the maximum value cannot exceed the range of angle marking pulse.

The range of angle marking pulse can be configured from 0.05° to 60°. The operate code of configure range of angle marking pulse is the same as the operate code of configure scan angle. The main reason is that if you want to gets the angle marking pulse within a certain range, you must make sure that the scan angle reach or exceed this range. For example, if you want to configure the angle marking pulse to have an output range of 58°, you must make sure that the scan angle reach 58°. If the rang of angle marking pulse to be configured is smaller than 50° of the A type or 55° of the B type, the scan angle is maintained at 50° of the A type or 55° of the B type, and the range of angle marking pulse is the angle you want to configure. For example, if the range of the angle marking pulse of the A-type is set to 30°, the scan angle of the is 50°, and the range of angle marker pulse is 30°, that means, angle marking pulse output only within ±15°.

The operate code of configure scan angle is [00(2-bit) + (Scan angle/0.01°)/2 (14-bit)]. For example, configure the scan angle to 56°, the operate code will be 0x0AF0 ([00+001010, 1111, 0000] (56°/0.01°/2 = 2800, the binary representation of 2800 is 0b00101011110000, and the hexadecimal representation of operate code is 0x0AF0).

The operate code of configure marking angle is [10(2-bit) + Scan angle/0.01° (14-bit)]. For example, configure the marking angle to 0.2°, the operate code will be 0x8017 ([10+000000, 0001, 0100] (0.2°/0.01°= 20, the binary representation of 20 is 0b00000000010100, and the hexadecimal operate code is 0x8017).

The operate code of configure angle of marking signal is same as the operate code of configure scan angle.

3.1.3 Query current parameters

The current parameters of P1100 can be acquired by sending the operate code: **0xC000**. After sending the operate code, there will be two 16-bit data returned. The scan angle and the marking angle can be got through the two 16-bit data. The first 16-bit data show the half of current scan angle. For example，the first 16-bit data are 0x0B54, that means the current scan angle is 58°. The second 16-bit data show the current marking angle. For example, the second 16-bit data are 0x0028, that means the current scan angle is 0.4°.

3.1.4 Working State

P1100 has five working states: Initializing, Configuring, Proper Functioning, Shutdown, and Failure. During the operation, the working status of the P1100 can be checked by sending the operate code: **0xF000** through SPI. Then P1100 reply a 16-bit data, which indicate the state of P1100, the data and state code list as table3-2.

Table 3-2 the state code and state of P1100

State code	State of P1100	Note
0xF000	Initializing	
0xF100	Configuring	
0xF200	Proper Functioning	
0xF300	Shutdown	
0xF301	Failure caused by voltage abnormality	
0xF302	Failure caused by feedback abnormality	

3.1.5 Shutdown

The scanning process and the angle marking pulse signal will stop immediately when the operator sending the shutdown code to the module. The shutdown code is **0xF800**.

3.1.6 Restoration

When P1100 is in shutdown state, the users can restart the P1100 by send the restart code: **0xF400**.

3.2 Real-time scanning position calculation

3.2.1 Angle Direction

For convenience, the P1100 artificially defines the angular direction. As shown in Figure 3-3. The P1100 is used to scan an external laser to illustrate the angular orientation of the P1100. In this figure, 0° labeled MEMS mirror is located on the zero position. The "+" and "-" reflection lines identify the positive and negative scan angles.

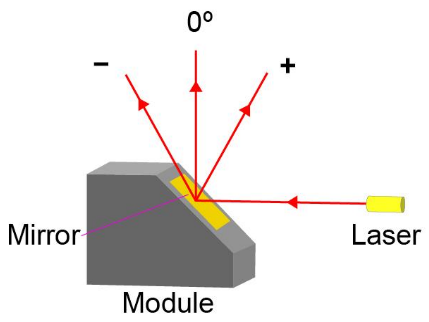


Figure 3-3 Angle Direction Design for P1100

The calculation of the real-time scanning position is based on the zero position marking pulse and the angle marking pulse. Figure 3-4 details the relationship between the zero positing marking pulse， the angle marking pulse and time in one scanning period.

This result is got by assuming the scan angle is 60° (±30°) and the incremental angle of angle marking pulse is 3°. In this diagram, the green line is the zero position marking pulse, which outputs only when the mirror pass through the zero position. In addition, this signal only outputs once in each period. As for the yellow line, it is the angle marking pulse, which outputs when the MEMS mirror scanning an incremental angle of angle marking pulse each time.

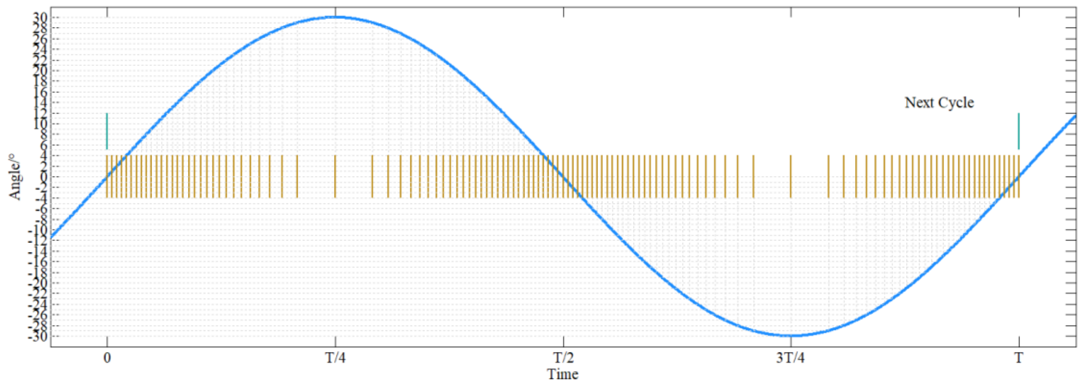


Figure 3-4 The relationship of the marking pulse signal and time,

Generally, the scan angle is 2Φ (±Φ) and the incremental angle of angle marking pulse is δ. In order to simplify the process of calculating the real-time scan position of the MEMS mirror, divided a period (T) into four parts as shown in Figure 3-5.

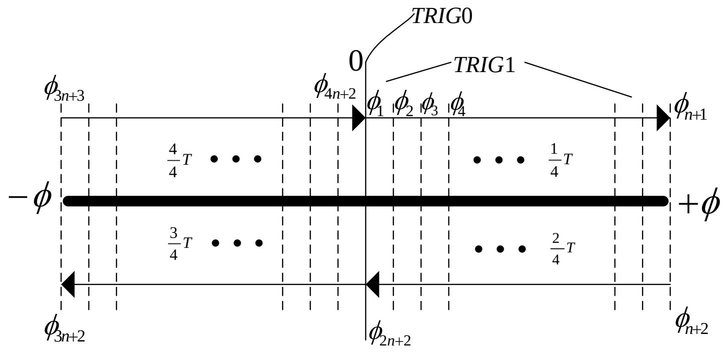


Figure 3-5 A period is divided into four parts

(1)In first 1/4 T

At the beginning of the period, a zero position marking pulse and an angle marking pulse will be output. After that, there will be an angle marking pulse when the MEMS mirror scanning an incremental angle of angle marking pulse each time, until this 1/4 T is over. The number of angle marking pulse in this 1/4 cycle is N+1. Where:

$$N = \Phi / \delta \quad \text{Formula (3-11)}$$

The example that shown in figure 3-5 has 11 angle marking pulses (from TRIG1).

(2)In second 1/4T

During this 1/4 cycle, the MEMS mirror will return to the zero position at the end. However, only the angle marking pulse will be output at this period. In this 1/4T, there are also N+1 angle marking pulses signal. In figure 3-5, the number of angle marking pulse (TRIG1) is 11.

(3) In third 1/4T

This 1/4 period is similarly to the first 1/4T. The angle marking pulse will be output when the MEMS mirror scanning an incremental angle of angle marking pulse, and the total number of the pulse during this 1/4 cycle is N. In figure 3-5, the number of angle marking pulse (TRIG1) is 10.

(4) In fourth 1/4T

At the end of this 1/4 cycle, the MEMS mirror will return to the zero position. It also means that a new period will start. During this time, the angle marking pulse will keep outputting and the total number of the pulse is N. In figure 3-5, the number of angle marking pulse (TRIG1) is 10.

Consequently, in one period, there will be totally 4*N+2 angle marking pulse output from TRIG1, and only one zero position marking pulse output from TRIG0. The zero position marking pulse is regarded as the beginning of a cycle. Setting the first 2*N+2 angle marking pulses are the positive scan angle, and the second 2*N angle marking pulses are the negative scan angle.

In a resonance period, the calculation formula of the real-time scanning position is:

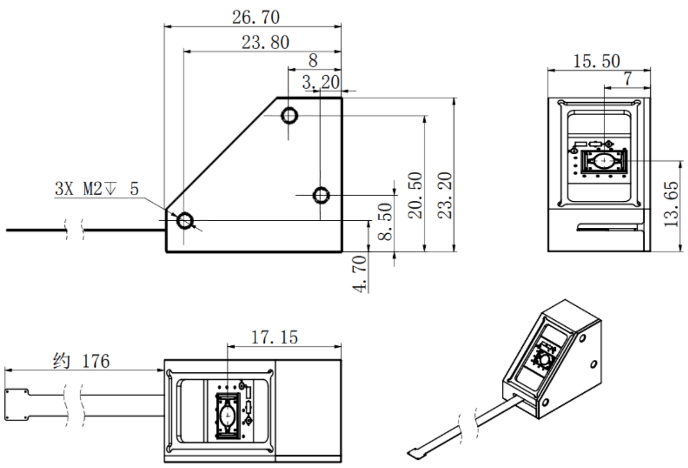
$$\Phi_i = \begin{cases} (i-1)*\delta & 1 < i \le N+1 \\ (2*N-i+2)*\delta & N+1 < i \le 2N+1 \\ 0 & i = 1, 2N+2 \\ -(i-2*N-2)*\delta & (2N+2) < i \le (3N+2) \\ -(4*N+3-i)*\delta & (3N+2) < i \le (4N+2) \end{cases}$$

Formula (3-2)

where N is calculated according to formula (3-1).

In particular, decide the positive and negative directions is a prerequisite for correctly measuring the real time scan angle. The positive and negative directions of the scan angle are marked on the shell of the P1100.

3.3 Dimension



unit: mm

Figure 3-6 Dimension of P1100

4. Evaluation

Our company has developed an official test board for testing the P1100, which is available for users to quickly evaluate P1100, and users can order it from our company. The physical structure of the test board is shown in figure 11.

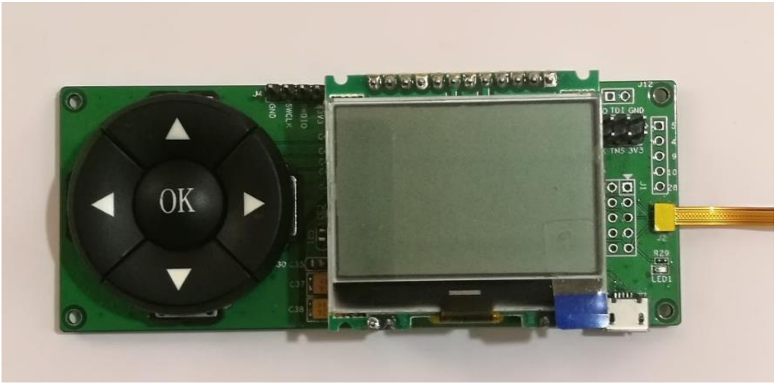


Figure 9 The official test board of P1100

For instructions on how to use test board, please refer to *Test Board for MEMS Mirror Module.*

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Revision History

Date	REV	Description
2017-4-28	V1.0	The first edition
2017-5-8	V1.1	Add product model description
2017-9-5	V1.2	Section 2.6.2：Correct the power consumption
2017-11-15	V1.2.1	Section 2.5：Correct the operating temperature of P1100
2017-12-20	V1.3	Section 3.2.2：Correct the dimension of P1100
2018-10-24	V1.3.1	Section 2.1：Limit the current of pin
2019-02-23	V1.4	The order of some chapters has been adjusted

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