

# High-Performance MEMS Gyroscope

MG100

## 1 Overview

The MG100 gyroscope is a domestically produced high-performance MEMS gyroscope. Its measurement range is  $\pm 100^\circ/\text{s}$  to  $\pm 1000^\circ/\text{s}$ .

The MG100 employs a low-noise, low-drift ASIC combined with a MEMS gyro structure to form a closed-loop system, enabling the gyroscope to achieve exceptional static performance, dynamic performance, and long-term stability.

The MG100 is housed in a standard CLCC48 package. It features SPI output, capable of outputting 24-bit angular velocity and 14-bit temperature values; data acquisition supports both synchronous and random acquisition modes. It includes a built-in configurable low-pass filter and built-in sensor status monitoring.

The MG100 is a compact, high-performance gyroscope with a simple peripheral circuit and user-friendly operation, making it an ideal sensor for high-performance inertial measurement and stabilization control.

### Features

- Fully digital closed-loop MEMS gyroscope
- Supply voltage: 4.75V to 5.25V
- Operating current:  $\leq 22\text{mA}$
- Operating temperature:  $-45^\circ\text{C}$  to  $+85^\circ\text{C}$
- Range (FS):  $\pm 100^\circ/\text{s}$  to  $\pm 1000^\circ/\text{s}$
- Output: SPI digital output
- Zero Drift Stability @ Constant Temperature:  $\leq 2.5^\circ/\text{h}$  (10-second smoothed standard deviation)
- Full-range zero drift stability (temperature-varying):  $\leq 10^\circ/\text{h}$  (10-second smoothed standard deviation)
- Angular random walk:  $\leq 0.12^\circ/\sqrt{\text{h}}$
- Full-scale nonlinearity @ FS =  $\pm 500^\circ/\text{s}$ : 200 ppm
- Bandwidth:  $\geq 200\text{ Hz}$
- Built-in 14-bit temperature sensor
- Supports on-chip temperature compensation
- Supports on-chip nonlinearity compensation
- Supports external synchronization
- Shock resistance: 4000g, 0.5 ms
- Package: CLCC48 (11.0 mm  $\times$  11.0 mm)

### Applications

- Inertial measurement
- Stabilization control
- Navigation Aids



## 2 Performance Specifications

See the table below for the product's main performance specifications.

**Table 2.1 Key Product Performance Parameters (Unless otherwise specified, @ 25 °C, AVDD = 5 V)**

Parameter	MG100-100	MG100-500	MG100-1000	Unit
Range	±100	±500	±1000	°/s
Zero Offset @ 25°C	15	45	100	°/h
White noise	≤0.001	≤0.002	≤0.003	°/s /√Hz
Zero-offset stability at constant temperature (10-second smoothing, 1σ)	≤1	≤2.5	≤5	°/h
Zero-offset drift over full temperature range (after temperature compensation, 10-second smoothed, 1σ)	≤2	≤10	≤10	°/h
Angular random walk	≤0.06	≤0.12	≤0.18	°/√h
Zero-bias repeatability (1σ)	≤1	≤3	≤6	°/h
Scale factor	50,000	10,000	5000	LSB/(°/s)
Scale factor repeatability (1σ)	≤100	≤100	≤100	ppm
Full-range temperature drift of scale factor (1σ)	300	300	300	ppm
Nonlinearity @ FS	≤200	≤200	≤200	ppm
Bandwidth (-3dB)	≥50	≥200	≥200	Hz
G Sensitivity	3	3	3	°/h/g
振动整流系数@6.06grms	0.1	0.1	0.1	°/h/g <sup>2</sup>
Temperature sensor zero point (@25°C)	-3800			LSB
Temperature sensor sensitivity	28.5			LSB/°C
Supply voltage	4.75–5.25			V
Start-up time	<1			s
Operating current	≤22			mA
Operating temperature range	-45 to +85			°C

### 3 Absolute Maximum Ratings

Table 3.1 Absolute Maximum Ratings

Parameter	Remarks	Minimum	Maximum	Unit
AVDD Voltage		-0.3	5.8	V
VDDIO voltage		-0.3	5.8	V
Analog pin voltage		-0.3	AVDD+0.3	V
Digital pin voltage		-0.3	VDDIO+0.3	V
Operating Temperature (Tj)		-55	+125	°C
Storage Temperature		-60	+150	°C
ESD rating	HBM Mode	-2	2	kV
Surge	0.5 ms half-sine	-	4000	g

Note:

(1) Maximum ratings represent the extreme conditions a device can withstand; performance is not guaranteed under these conditions. Exceeding these limits may cause device damage, and prolonged operation at absolute maximum ratings may lead to device failure.

(2) External digital power supply voltage VDDIO: When the external SPI communication system is 5V, the VDDIO supply voltage is 5V; when the external SPI communication system is 3.3V, the VDDIO supply voltage is 3.3V; when the external SPI communication system is 1.8V, the VDDIO supply voltage is 1.8V.

#### ESD Warning



ESD [Electrostatic Discharge] sensitive device. Charged devices and circuit boards may discharge without warning. Although this product features dedicated protection circuits, the device may be damaged if exposed to high-energy ESD. Therefore, appropriate ESD precautions should be taken to prevent performance degradation or loss of functionality.

### 4 Pin and Function Descriptions

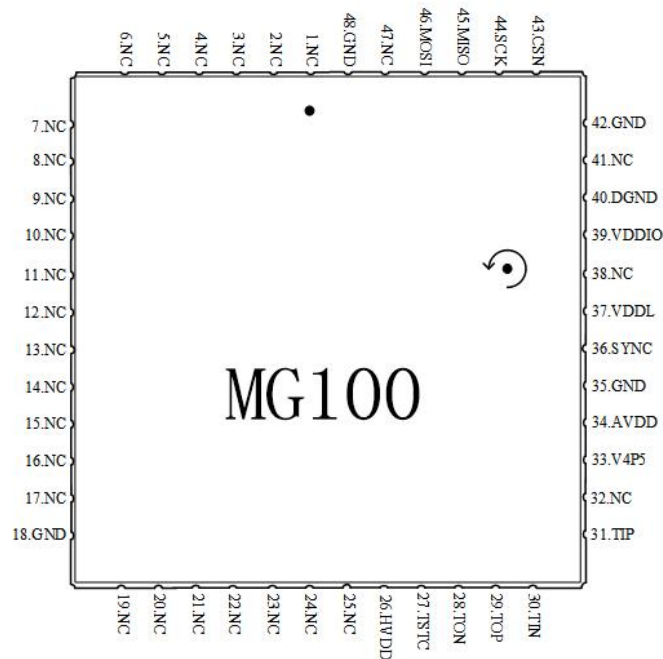


Figure 4.1 Chip Pinout

Table 4.1 Pin Function Description

No.	Pin Name	Pin Attribute	Pin Definition	Remarks
26	HVDD	Internal Power Supply	High-Voltage Output	Maximum voltage 16V. External 4.7uF capacitor.
27	TSTC	Analog	Reserved pin	Leave floating when in use.
28	TON	Analog	Reserved pin	Leave floating when in use.
29	TOP	Analog	Reserved pin	Leave floating when in use.
30	TIN	Analog	Reserved pin	Leave floating when in use.
31	TIP	Analog	Reserved pin	Leave floating when in use.
33	V4P5	Analog	4.5V reference output	4.5V output; connect a 1uF capacitor nearby.
34	AVDD	Power Supply	Analog Power Supply	5V analog power supply.
36	SYNC	Digital	Synchronization input pin	Synchronization signal input; leave floating when not in use.
37	VDDL	Internal Power Supply	CORE power supply	Connect an external 100 nF capacitor.
39	VDDIO	IO Power Supply	IO Power Supply	IO power supply range: 1.7 V to 5.25 V.
43	CSN	Digital	SPI Chip Select	Low active; external pull-up recommended.
44	SCK	Digital	SPI clock input	SPI clock input, . An external pull-down is recommended.
45	MISO	Digital	SPI Output	SPI data output.

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46	MOSI	Digital	SPI Input	SPI data input; external pull-down recommended.
1-17, 19-25, 32, 38, 41, 47	NC	-	-	Left floating.
18, 35, 42, 48	GND	Analog Ground	Analog Ground	Connect to analog ground.
40	DGND	Digital Ground	Digital ground	Connect to digital ground.

## 4.1 Pin Description

### (1) AVDD:

The typical supply voltage for AVDD is 5V, with a voltage range of 4.75V to 5.25V. Power supply ripple must be less than 50mVpp. During power-up, the AVDD voltage must rise monotonically and continuously. During power-down, the voltage must be reduced to below 10% of AVDD (5V). The AVDD pin is filtered using a 0.1uF + 10uF ceramic capacitor.

### (2) VDDIO:

Reference voltage input for external communication. The I/O power supply (VDDIO) voltage is selectable between 1.8V, 3.3V, and 5.0V. It is filtered using a 0.1µF ceramic capacitor. Select the appropriate voltage based on the connected external communication interface; the voltage range is 1.7V to 5.25V. During VDDIO power-up and power-down, ensure that the voltage rises and falls monotonically and continuously. Voltage fluctuations during the VDDIO power-up process may cause the device to reset multiple times, resulting in irreversible damage.

### (3) SPI:

The gyroscope communicates via a 4-wire SPI interface and operates in slave mode (MODE0). Set CSN to low to initialize communication. Data changes on MISO and MOSI must be synchronized with the falling edge of SCK, while master-slave sampling inputs must be synchronized with the rising edge of SCK.

### (4) AVDD / VDDIO Timing Requirements:

There is no specific sequence requirement for powering up or down AVDD and VDDIO. The rise time for AVDD power-up is less than 200 µs, and the fall time for power-down is less than 200 ms. The rise time for VDDIO power-up and the fall time for power-down are both less than 200 ms. The interval between two consecutive power-ups of AVDD and VDDIO should be greater than 500 ms.

## 5 Recommended Application Circuit

A typical application circuit is shown in Figure 5.1.

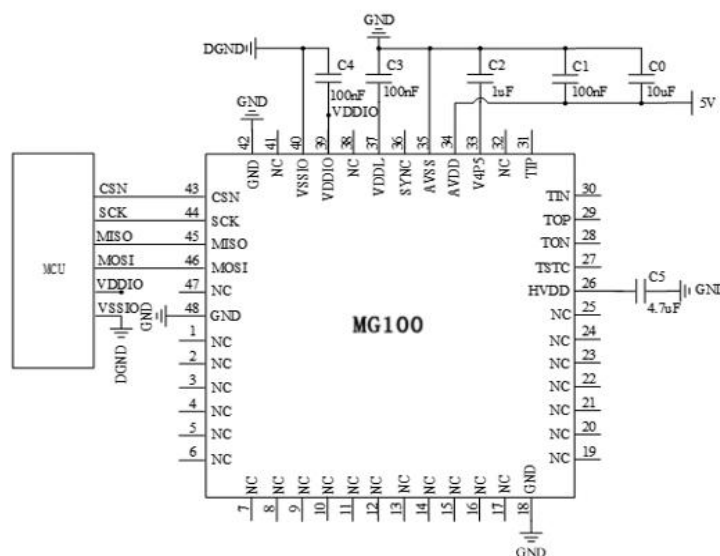


Figure 5.1 Typical Application Circuit Diagram

## 6 PCB Layout and Routing Recommendations

MEMS sensors are highly sensitive to mechanical and thermal stress. Therefore, PCB designers are advised to follow the recommendations below.

- (1) The device should be placed as far as possible from high-stress areas such as mounting screws, connectors, and PCB edges;
- (2) The device should be avoided in areas prone to high thermal stress;
- (3) It is recommended to select PCB materials with the highest possible hardness and thermal stability. For PCBs smaller than 30 mm × 30 mm, the recommended thickness is 1.2 mm or greater; otherwise, the PCB thickness should be 1.6 mm or greater;
- (4) When using components that may generate mechanical vibration, such as power inductors, place them away from the sensor or on a separate PCB, while ensuring isolation from vibration stress;
- (5) It is recommended to secure the PCB using adhesive (which can effectively reduce high-frequency impacts and prevent component damage). When securing the PCB, avoid allowing the structural adhesive to adhere to the components, as this may affect their full-temperature performance.
- (6) Decoupling capacitors for the HVDD, V4P5, AVDD, VDDL, and VDDIO pins should be placed as close to the pins as possible, and the equivalent resistance of the traces should be minimized. Additionally, ensure that the traces in this area are routed away from those of the SPI communication interface. Power lines should use wider PCB traces to ensure voltage stability.
- (7) When SPI communication speeds are high, it is recommended to perform impedance matching and equal-length routing.
- (8) To ensure the device is mounted flat, it is not recommended to route traces under the package, drill through-holes, or drill through pads.

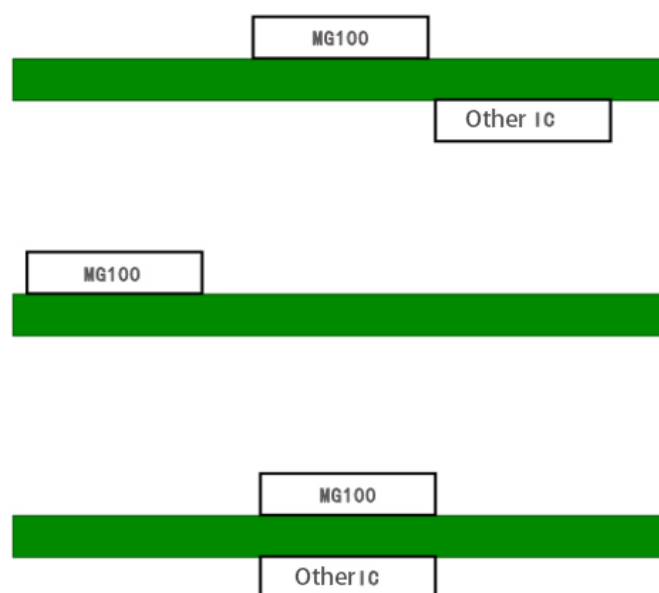


Figure 6.1 PCB Placement Recommendations

## 7 Recommendations for Soldering and Panel Separation

The internal sensing elements of this sensor are relatively fragile. It is recommended to perform soldering after panel separation. If the PCB is small, it is recommended to create a corresponding soldering jig, or to separate the panel after other components have been soldered, and then solder this chip after separation.

Note: Do not separate the board mechanically (by directly snapping it apart, milling, etc.) after the chip has been soldered, as the mechanical stress generated during separation may cause permanent damage to the chip.

## 8 SPI Interface Specifications

Communication uses 4-wire SPI Mode 0 (CPOL = 0, CPHA = 0). Supports a maximum clock rate of 10 MHz.

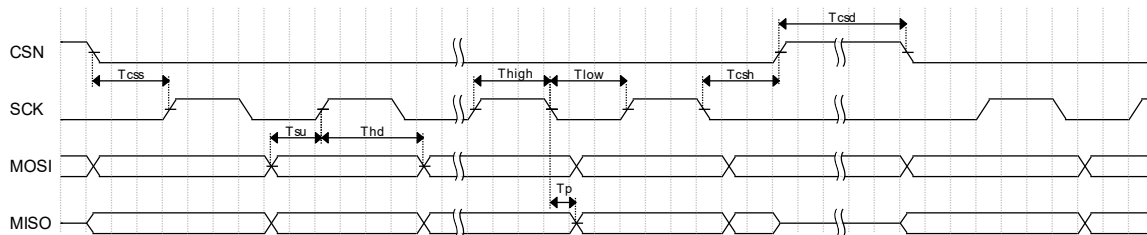


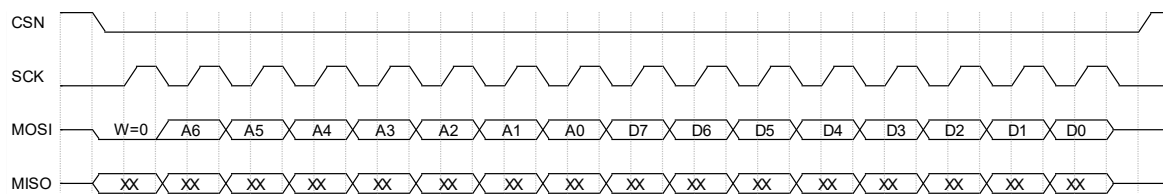
Figure 8.1 SPI Timing Diagram

Table 8.1 SPI Interface Electrical Characteristics

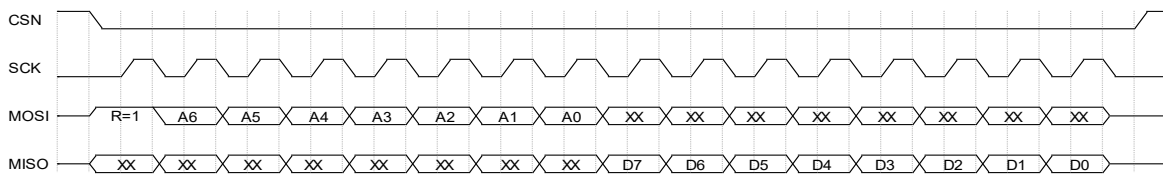
Parameter	Symbol	Test Conditions/Remarks	Minimum	Maximum	Unit
<b>Digital Input DC Characteristics</b>	VHI		0.8*VDDIO		V
High Level	VIL			0.2*VDDIO	V
<b>Digital Output DC Characteristics</b>	VOH	@10 mA sink current	0.8 × VDDIO		V
High Level	VOL	@10 mA current injection		0.2*VDDIO	V
Low Level		@Output High		20	mA
Draw Current		@Output Low	-20		mA
Sink Current					
<b>Digital Signal AC Characteristics</b>	Fsck		0.1	10	MHz
SCK frequency	Thigh		50		ns
SCK High Duration	Tlow		50		ns

SCK Low Duration	Tcss		50		ns
CSN setup time	Tcsh		50		ns
CSN Hold Time	Tcsd		100		ns
CSN Disable Time	Tsu		25		ns
MOSI rise time	Thd		50		ns
MOSI hold time	Tp			25	ns
MISO propagation delay					

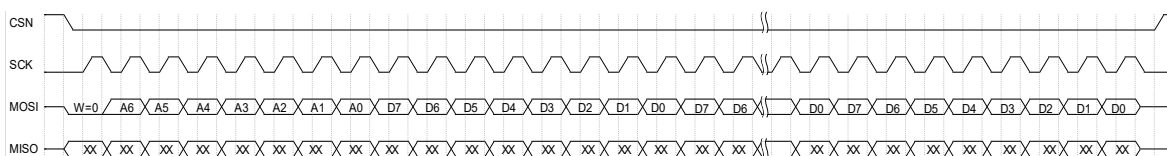
**SPI Read/Write Control**



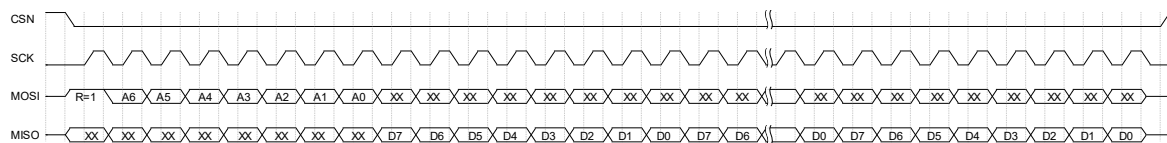
**Figure 8.2 SPI Single-Byte Write Timing**



**Figure 8.3 SPI Single-Byte Read Timing**



**Figure 8.4 SPI Multi-byte Write Timing**



**Figure 8.5 SPI Multi-byte Read Timing**

Note:

- W/R: SPI Read/Write Control Bit
  - 0: SPI write operation
  - 1: SPI read operation
- A6–A0: SPI Operation Address
  - Range: 0x00 to 0x7F
- D7–D0: SPI Data

Range: 0x00 to 0xFF

When the most significant bit of the register address is 0, it indicates a write operation to the register; when the most significant bit of the register address is 1, it indicates a read operation from the register.

**Register Mapping**

Register Address: 0x51

Register Attribute: Read-Only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
DRDY	GOUT[23:17]						
Sensor data update flag. DRDY = 1: Data has been updated; regardless of whether the data is read, the latest data will be automatically updated internally at a rate of 32 kHz; DRDY = 0: Data has not been updated; Sensor angular velocity output, GOUT [23:17].							

Register address: 0x52

Register Attribute: Read-Only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
GOUT[16:9]							
Sensor angular velocity output, GOUT [16:9].							

Register address: 0x53

Register attribute: Read-only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
GOUT[8:1]							
Sensor angular velocity output, GOUT [8:1].							

Register address: 0x54

Register Attribute: Read-only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
GOUT[0]	ERR	TEMP[13:8]					
Sensor angular velocity output, GOUT [0]. Sensor error flag: ERR = 1: Error; ERR = 0: OK.							

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Sensor temperature output, TEMP [13:8].

Register address: 0x55

Register attributes: Read-only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
TEMP[7:0]							
Sensor temperature output, TEMP [7:0].							

Register address: 0x56

Register Attribute: Read-only

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit0
CHECKSUM7:0]							
Checksum of sensor data output, Bits [7:0].							

Register address: 0x5E

Register Attributes: Read/Write

Bit7	Bit6	Bit 5	Bit 4	Bit 3	Bit 2	Bit1	Bit 0
0	1	IIRBW[2:0]			0		
<p>Bit 7 is a reserved bit; default value is 0;</p> <p>Bit 6 is a reserved bit; default value 1;</p> <p>IIRBW[2:0]: IIR filter bandwidth selection;</p> <p>IIRBW[2:0] = 3'b 000: Pass-through;</p> <p>IIRBW[2:0] = 3'b 001: 80 Hz;</p> <p>IIRBW[2:0] = 3'b 010: 160 Hz;</p> <p>IIRBW[2:0] = 3'b 011: 300 Hz;</p> <p>IIRBW[2:0] = 3'b 100: 500 Hz (default);</p> <p>IIRBW[2:0] = 3'b 101: 900 Hz.</p> <p>Bit2, Bit1, and Bit0 are reserved; default value is 3'b000,</p>							

Register address: 0x5F

Register attributes: Read/Write

Bit7	Bit 6	Bit5	Bit 4	Bit 3	Bit 2	Bit1	Bit 0
0			HREG_EN	0		SYNC_EN	0
Bit 7, Bit 6, and Bit 5 are reserved bits; default value is 3'b000;							

HRGE\_EN configures the register enable; HRGE\_EN = 0: Factory configuration (IIR filter default bandwidth 500 Hz, random acquisition mode)

HRGE\_EN = 1: When set to 1, the user can reconfigure the IIR filter bandwidth and enable synchronous acquisition mode; users should configure the bandwidth with caution;

Bit 3 and Bit 2 are reserved; default value is 2'b00.

SYNC\_EN Synchronization Enable, SYNC\_EN = 0: Disabled (data update rate 32 Ksps)

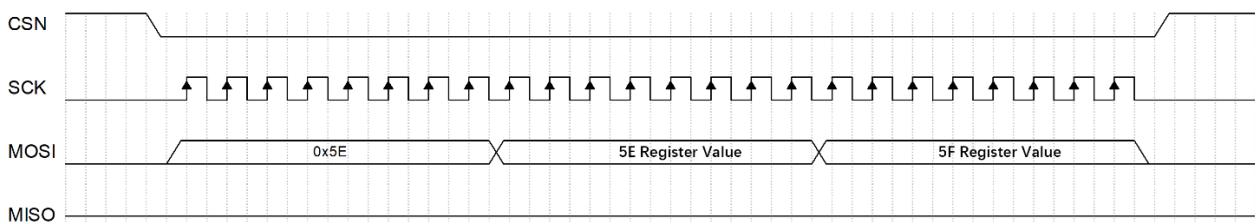
SYNC\_EN = 1: Enabled (data output rate equals the SYNC pulse frequency).

Bit0 Reserved, default value 1'b0.

**Note:**

1. Reserved bits in writable registers must be configured according to the recommended default values; modification may result in sensor malfunction.

2. 0x5E and 0x5F ( ) are power-off volatile registers. Registers 0x5E and 0x5F must be configured consecutively; they need to be configured only once after power-up. The configuration timing is shown in Figure 8.6.



**Figure 8.6 Configuration Timing Diagram for Registers 5E and 5F**

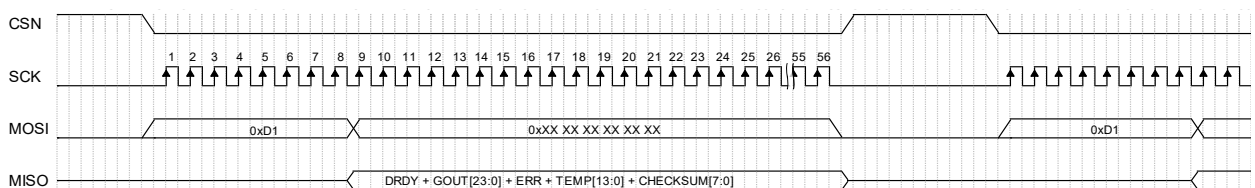
## SPI Data Read

### Random Continuous Acquisition ( ) Mode

Send 0xD1 followed by 6 bytes of arbitrary data to the MG100 to read data registers 0x51, 0x52, 0x53, 0x54, 0x55, and 0x56. The MG100 will then begin transmitting data in the packet format: .The data packet is 48 bits long and contains 1 bit for the data ready flag (DRDY), 24 bits for the output rate (GOUT), 1 bit for the error flag (ERR) , 14 bits for temperature (TEMP), and 8 bits for the checksum (CHECKSUM).

DRDY	GOUT [23:0]	ERR	TEMP[13:0]	CHECKSUM [7:0]
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**where CHECKSUM[7:0] = GOUT[23:16] + GOUT[15:8] + GOUT[7:0] + {2'b0, TEMP[13:8]} + TEMP[7:0].**



**Figure 8.7 SPI Data Acquisition Timing Diagram**

When data is updated, DRDY is set to '1' . After the data is acquired, DRDY is cleared to '0'; when the

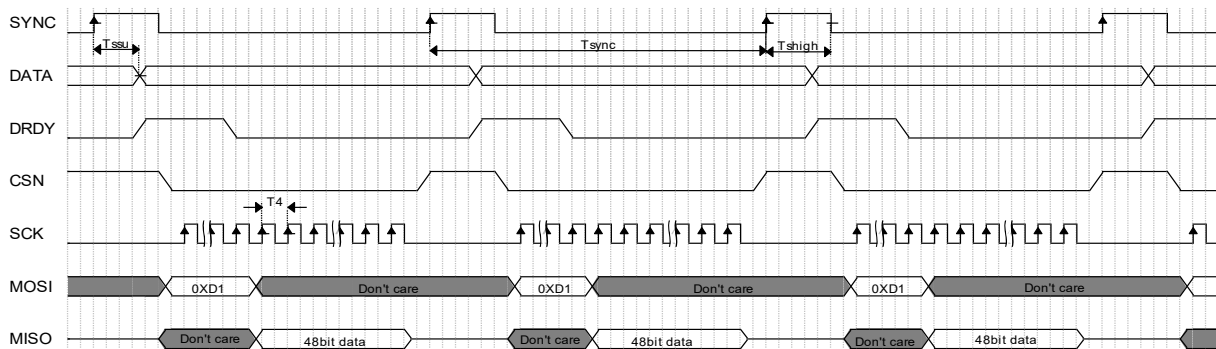
data is updated again, DRDY is set to '1'. GOUT [23:0] and TEMP[13:0] are all signed numbers, with the most significant bit being the sign bit.

**Table 8.2 Data Conversion Relationship Between GOUT[23:0] and TEMP[13:0] (Two's Complement)**

GOUT[23:0]		TEMP[13:0]	
Hexadecimal	Decimal	Hex	Decimal
24'h7fffff	24'd8388607	14'h1fff	14'd8191
...	...	...	...
24'h000001	24'd1	14'h0001	14'd1
24'h000000	24'd0	14'h0000	14'd0
24'hffffff	-24'd1	14'h3fff	-14'd1
...	...	...	...
24'h800000	-24'd8388608	14h2000	-14'd8192

### Synchronous Acquisition Mode

Set the SYNC\_EN register to 1 to enable synchronous acquisition; data synchronization occurs on the rising edge of the SYNC pin.



**Figure 8.8 Synchronous Acquisition Timing (SYNC\_EN=1)**

**Table 8.3 External Synchronous Acquisition Timing Description**

Parameter	Symbol	Minimum	Maximum	Unit
SCK Frequency	/	/	10	MHz
Time from SYNC rising edge to data update	Tssu	25	/	us
SYNC high-level hold time	Tshigh	25	/	us
SYNC Period	Tsync	40	/	ms

The output data is stored in a 6-byte register (1-bit DRDY, 24-bit angular velocity data, 1-bit ERR, 14-bit temperature data, 8-bit checksum). When the data is updated, these 6 bytes are updated in the corresponding byte order. During this process, to ensure that the read register contains the latest data rather than duplicate data, the DRDY flag can be checked. When the data in the register is the latest valid data, DRDY is set to 1; when reading data from the temperature and angular velocity registers, this flag is automatically cleared. If

the data has not been updated and is read again, DRDY is 0, indicating that the data read is a duplicate and should be discarded.

The recommended data read procedure is to send 0XD1+6bytes00. If DRDY=1 and the CHECKSUM is correct, save the data; if DRDY=0 or the CHECKSUM is incorrect, discard the data. You may optionally verify the CHECKSUM to ensure the integrity of the data transmission process.

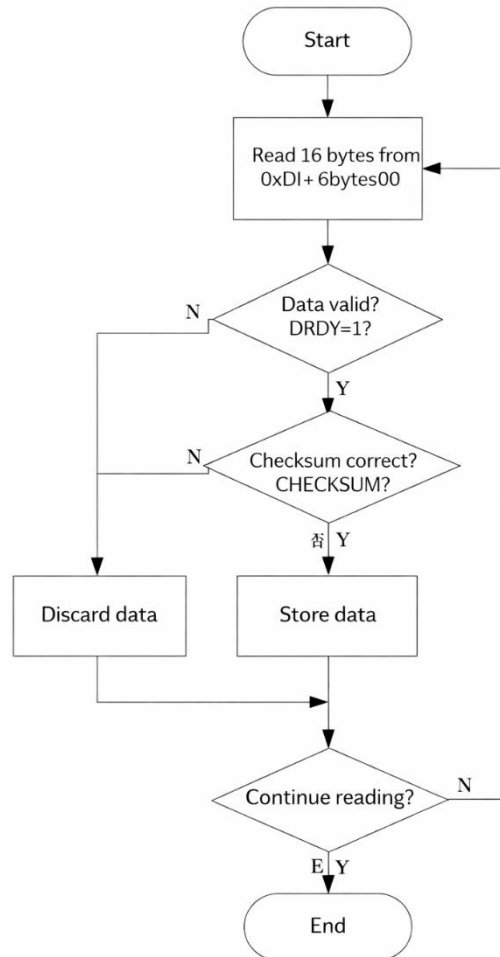
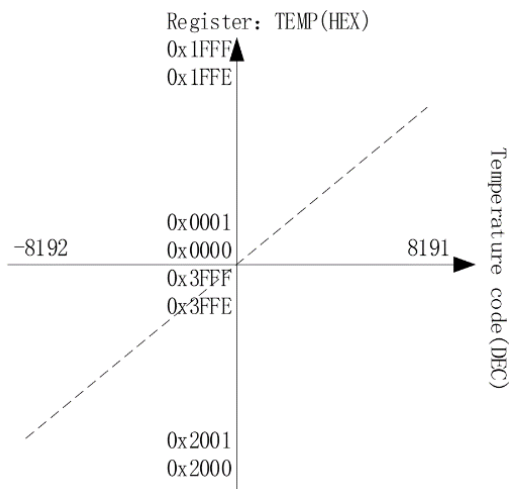


Figure 8.9 Data Read Flowchart

## 9 Data Output Calculation

### Temperature Data Output



Temperature data is 14 bits wide in two's complement format, with the most significant bit serving as the sign bit.

The relationship between the temperature sensor value and the actual temperature can be roughly described by the following formula:

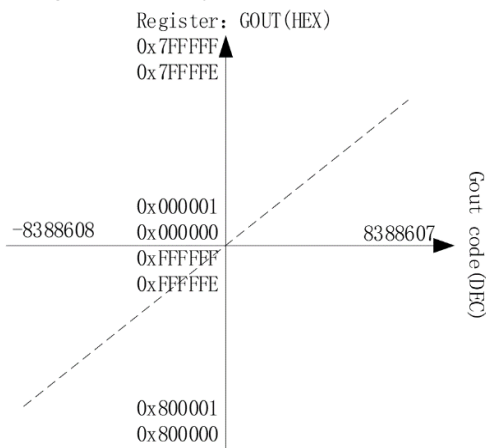
$$\text{Actual Temperature}(\text{°C}) = \frac{\text{Temperature code(DEC)} - (-3800)}{\text{Temperature Scale Factor}} + 25$$

It should be noted that the temperature sensor's output signal is typically used as a compensation parameter; therefore, only relative accuracy is required. Furthermore, since the

temperature sensor is located inside the chip, the actual temperature is primarily affected by the chip's self-generated heat. Consequently, the temperature sensor's output has not been precisely calibrated to Celsius values. The actual Celsius temperature derived from the formula is only a rough reference and cannot be used to measure the ambient temperature of the chip's environment.

### Angular Velocity Data Output

Angular velocity data is 24-bit wide, in two's complement format, with the most significant bit being the



sign bit. The relationship between the gyroscope sensor value and the actual angular velocity can be calculated using the following formula:

$$\text{Angular Velocity}(\text{°/s}) = \frac{\text{Gout code(DEC)}}{\text{Scale Factor}}$$

Due to the product's customization process, the value of `Scale Factor` in the formula must be referenced from the quality inspection report provided at the time of shipment.

## 10 Recommended Soldering Method

The MG100 series devices are high-precision MEMS gyroscopes. To ensure optimal performance and reliability, observe the following soldering precautions: Place the device on a stable surface without vibration; ensure each pin is soldered evenly; ensure the device is parallel to the application circuit board; and ensure the force applied to the entire device is uniform.

Sn63Pb37 solder is recommended for the MG100 series devices.

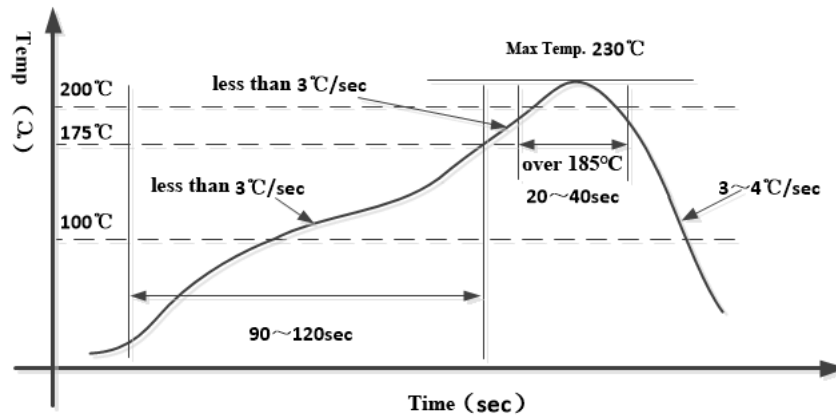


Figure 10.1 Recommended Soldering Profile

In actual use, adjust the above parameters appropriately based on the selected soldering materials (peak temperature should not exceed 230°C).

**Note: After reflow, do not use ultrasonic cleaning to avoid damaging the device's internal micro-electromechanical system.**

11 Dimensions

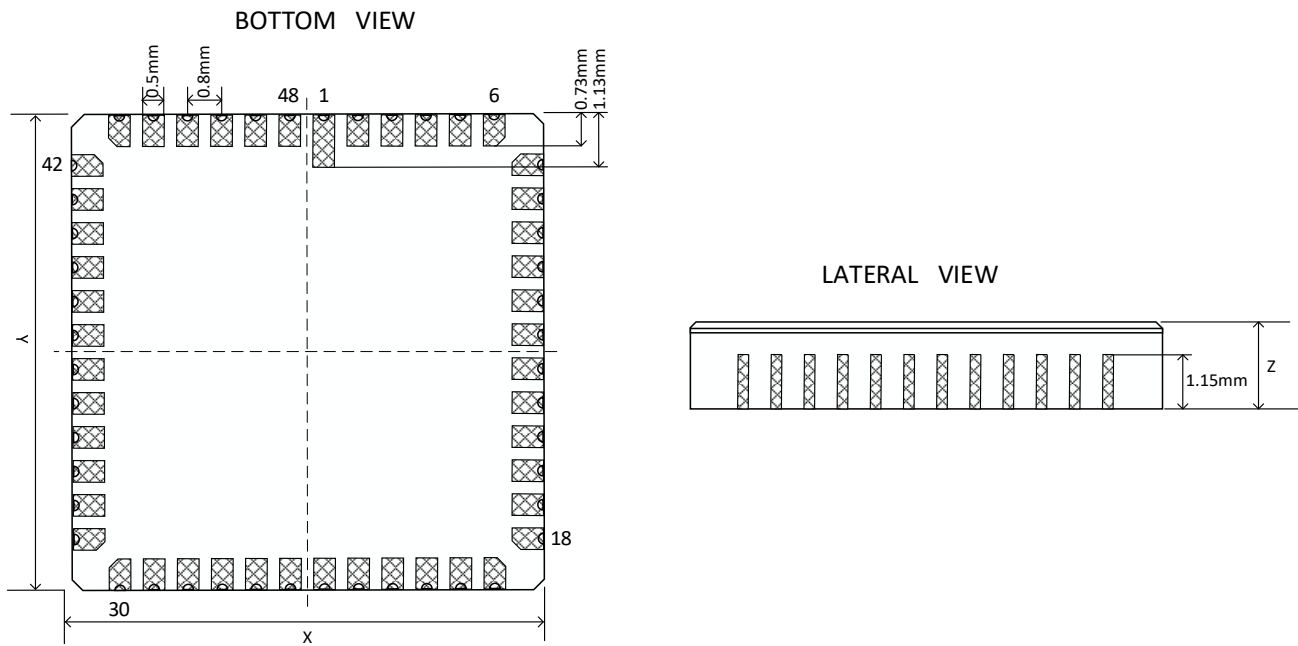


Figure 11.1 Chip Dimensions (Left: Bottom View, Right: Side View)

Table 11.1 Package Dimensions

Parameter	Description	Minimum	Average	Maximum	Unit
Pin Processing	Gold Plating	1.3	-	-	μm
	Nickel plating	1.3	-	-	μm
Weight		-	0.7	-	grams
Dimensions	X	10.70	11.00	11.30	mm
	Y	10.70	11.00	11.30	mm
	Z	1.50	1.80	2.10	mm
Package	CLCC substrate + metal cap, 48-pin				
Axis Alignment Reference Plane	Use the bottom of the CLCC substrate as the alignment reference plane; do not use the surface of the metal cap as the alignment reference plane				
Axial Description	Per the right-hand rule, perpendicular to the chip cap, pointing from the chip solder side toward the cap				

10 Silkscreen Markings

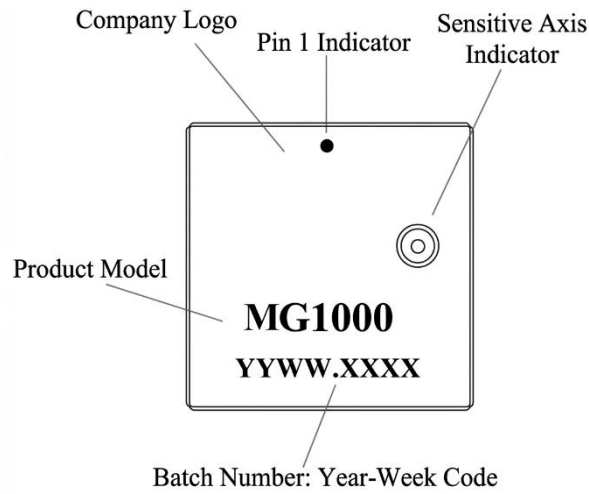


Figure 10.1 Chip Marking Instructions

Model Selection Notes

XX ↓ Type	X ↓ Series	XXX ↓ Range	X ↓ Class	X ↓ Custom
<b>MG: Gyroscope Components</b>	<b>100</b>	100: ±100°/s	<b>H: Industrial grade (default: blank)</b>	<b>Custom (default: blank)</b>
		500: ±500°/s	S: Custom	
		1000: ±1000°/s	A: Commercial Grade	
Example: MG100 series with a range of ±500°/s, single-axis industrial-grade gyro instrument				

Table 10.1 Model Description Table

Model	Range	Remarks
MG100-100	±100°/s	-
MG100-500	±500°/s	-
MG100-1000	±1000°/s	-

## 11 Revision History

Revision	Date	Description
V0.1	January 2025	Initial Release
V1.0	May 2025	Official Release
V1.1	July 2025	Added Figure 6 (Digital Filter Architecture Diagram) on Page 9
V1.2	August 2025	Modified Figure 2 on Page 5: Ground pin connection, height tolerance, and scale factor
V1.3	November 2025	Corrected Page 2 to adjust the FG1501 bandwidth to 200 Hz; added pin descriptions; added PCB layout and routing recommendations; added recommendations for soldering split boards; provided more detailed explanations of registers; added sample code for sensor data acquisition;

Appendix: Sensor data acquisition sample code using the STM32H725ZGT3 as an example, utilizing HAL library functions, with a compilation environment of Keil V5.43 and ARM Compiler V5.06.

```
static uint8_t spi_10Hz_collectData_singleChannel(uint16_t ch) // [cite: 131]
{ // [cite: 132]
    uint8_t w_data[7] = {0xD1}; // Read 0x51 data register command [cite: 133]
    uint8_t rev_data[7] = {0}; // Sensor SPI read return value [cite: 134]
    uint8_t checkSum = 0; // Checksum bit [cite: 135]
    uint32_t Vout = 0; // Data conversion intermediate variable [cite: 136]
    int midVout = 0; // Sensor data output value [cite: 137]
    int midTemp = 0; // Sensor temperature output value [cite: 138]
    uint16_t temp = 0; // [cite: 139]
    uint8_t ret = 1; // [cite: 140]

    HAL_GPIO_WritePin(HardSPI_Channels[ch].CS_Port, HardSPI_Channels[ch].CS_Pin, GPIO_PIN_RESET); // Pull down
    CS [cite: 141]
    HAL_SPI_TransmitReceive(HardSPI_Channels[ch].hspi, (uint8_t*)w_data, (uint8_t*)rev_data, 7u, 0xFFFF); // SPI reads
    sensor data [cite: 142]
    HAL_GPIO_WritePin(HardSPI_Channels[ch].CS_Port, HardSPI_Channels[ch].CS_Pin, GPIO_PIN_SET); // Pull up CS [cite:
    143]

    Vout = (uint32_t)(((rev_data[1] & 0x7F) << 17) | (rev_data[2] << 9) | (rev_data[3] << 1) | ((rev_data[4] & 0x80) >> 7)); // [cite:
    144]
    // Sensor 24-bit angular velocity data bit concatenation [cite: 145]

    temp = (uint16_t)(((rev_data[4] & 0x3F) << 8) | rev_data[5]); // Sensor 14-bit temperature data bit concatenation [cite: 146]

    if ((rev_data[1] & 0x80) == 0x80) // Judge data DRDY [cite: 147]
    { // [cite: 148]
        checkSum = *((uint8_t*)&Vout + 0) + *((uint8_t*)&Vout + 1) + *((uint8_t*)&Vout + 2) + *((uint8_t*)&Vout + 3) +
```

```
*((uint8_t*)&temp + 0) + *((uint8_t*)&temp + 1); // [cite: 149]

if (checkSum == rev_data[6])// Judge data verification result [cite: 150]
{ // [cite: 151]
    if (Vout >= 0x800000)// Calculate angular velocity positive/negative using two's complement [cite: 152]
    { // [cite: 153]
        midVout = (int)((-1) * (0x1000000 - Vout)); // [cite: 154]
    } // [cite: 155]
    else // [cite: 156]
    { // [cite: 157]
        midVout = (int)(Vout); // [cite: 158]
    } // [cite: 159]

    if (temp >= 0x2000) // Calculate temperature positive/negative using two's complement [cite: 160]
    { // [cite: 161]
        midTemp = (int)((-1) * (0x4000 - temp)); // [cite: 162]
    } // [cite: 163]
    else // [cite: 164]
    { // [cite: 165]
        midTemp = (int)(temp); // [cite: 166]
    } // [cite: 167]
} // [cite: 168]
else // [cite: 169]
{ // [cite: 170]
    // Verification error handling [cite: 171]
} // [cite: 172]
} // [cite: 173]
else // [cite: 174]
{ // [cite: 175]
    // Data not updated handling [cite: 176]
} // [cite: 177]

return ret; // [cite: 178]
} // [cite: 179]
```

The code above reads sensor data via SPI, where midVout and midTemp represent the angular velocity output and sensor temperature output, respectively, in LSB units.