HWT101 Protocol

Register Table

ADDR (Hex)	ADDR (Dec)	REGISTER NAME	FUNCTION	SERIAL I/F	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit0
00	00	SAVE	Save/Restart /Restore to Factory	R/W	SAVE[15:0]															
03	03	RRATE	Output rate	R/W													RRATE[3:0]			
04	04	BAUD	Serial port baud rate	R/W													BAUD[3:0]			
1A	26	IICADDR	Device Address	R/W									IICADDR[7:0]							
1B	27	LEDOFF	Turn off LED lights	R/W																LED OFF
27	39	READADDR	Read Register	R/W									READADDR[7:0]							
2E	46	VERSION	Version Number	R	VERSION[15:0]															
30	48	YYMM	years	R/W	MOUTH[15:8]								YEAR[7:0]							
31	49	DDH	Date and time	R/W	HOUR[15:8]								DAY[7:0]							
32	50	MMSS	Minutes and seconds	R/W	SECONDS[15:8]								MINUTE[7:0]							

33	51	MS	millisecond	R/W	MS[15:0]
38	56	GY	Angular velocity Y	R	GY[15:0]
39	57	GZ	Angular velocity Z	R	GZ[15:0]
3F	63	Yaw	Heading Angle	R	Yaw[15:0]
41	65	AUTOPTP	Automatically obtain zero bias peak-to-peak value	R/W	AUTOPTP[15:0]
43	67	AUTOT	Automatically obtain zero bias time	R/W	AUTOT[15:0]
44	68	AUTOTH	Automatically obtain zero bias threshold	R/W	AUTOTH[15:0]
48	72	WORKMODE	Working Mode	R/W	WORKMODE[2:0]
4A	74	GYROPTP	Z-axis static peak-to-peak value	R/W	GYROPTP[15:0]
4B	75	GPTPTIME	Z-axis peak-to-peak acquisition time	R/W	GPTPTIME[15:0]
4C	76	GYROBAIS	Z-axis zero offset	R/W	GYROBAIS[15:0]

4D	77	GBAISSTIME	Z-axis zero offset acquisition time	R/W	GYROBAIS[15:0]
4E	78	GSTATICTHRE	Z-axis stationary threshold	R/W	GSTATICTHRE[15:0]
4F	79	GSTATICTIME	Z-axis stabilization time	R/W	GSTATICTIME[15:0]
50	80	PGSCALE	Z-axis calibration factor P	R/W	PGSCALE[15:0]
52	82	GSCALERANGE	Z-axis calibration angle	R/W	GSCALERANGE[15:0]
61	97	GYROCALITHR	Static detection threshold	R/W	GYROCALITHR[15:0]
63	99	GYROCALTIME	Gyroscope automatic calibration time	R/W	GYROCALTIME[15:0]
6A	106	WERROR	Gyroscope change value	R/W	GYROPTP[15:0]
6E	110	WZTIME	Angular velocity continuous stationary time	R/W	WZTIME[15:0]
6F	11	WZSTATI	Angular	R/W	WZSTATIC[15:0]

	1	C	velocity integral threshold		
74	116	MODDELAY	485 data response delay	R/W	MODDELAY[15:0]
76	118	CALIYAW	Z axis angle reset	R/W	CALIYAW[15:0]

Read format

- The data is sent in hexadecimal format, not ASCII.
- Each data is transmitted in sequence with low byte and high byte, and the two are combined into a signed short type data. For example, data DATA1, where DATA1L is the low byte and DATA1H is the high byte. The conversion method is as follows: Assuming that DATA1 is the actual data, DATA1H is its high byte part, and DATA1L is its low byte part, then: DATA1=(short)((short) DATA1H <<8| DATA1L). It must be noted here that DATA1H needs to be forced to be converted to a signed short type data before shifting, and the data type of DATA1 is also a signed short type, so that negative numbers can be represented.

Protocol Header	Data content	Data lower 8 bits	Data high 8 bits	Data lower 8 bits	Data high 8 bits	Data lower 8 bits	Data high 8 bits	Data lower 8 bits	Data high 8 bits	SUM CRC
0x55	TYPE【1】	DATA1L[7:0]	DATA1H[15:8]	DATA2L[7:0]	DATA2H[15:8]	DATA3L[7:0]	DATA3H[15:8]	DATA4L[7:0]	DATA4H[15:8]	SUM CRC【2】

【1】TYPE(data content):

TYPE	Remark
0x52	Angular velocity
0x53	angle

【2】SUMCRC (data and check):

SUMCRC=0x55+TYPE+DATA1L+DATA1H+DATA2L+DATA2H+DATA3L+DATA3H+DATA4L+DATA4H

SUMCRC is of type char, and takes the lower 8 bits of the checksum

Angular velocity output

0x55	0x52	0x00	0x00	Wlq	Wlq	Wlq	Wlq	0x00	0x00	SUM

name	describe	Remark
0x00	Meaningless	
0x00	Meaningless	
Wlq	Angular velocity Y lower 8 bits	Angular velocity y = ((WzH<<8)|WzL)/32768*2000°/s【1】
Wlq	Angular velocity Y high 8 bits	
Wlq	Angular velocity Z low	Angular velocity Z =

	8 bits	((WzH<<8)|WzL)/32768*2000°/s【2】
Wlq	Angular velocity Z high 8 bits	
0x00	Meaningless	
0x00	Meaningless	
SUM	Checksum	SUM=0x55+0x52+WyL+WyH+WzL+WzH

【1】Raw data of angular velocity Y

【2】The angular velocity Z obtained after the original data of angular velocity Z is calibrated

Angle output

0x55	0x53	0x00	0x00	0x00	0x00	YawL	Yaw	V L	VH	SUM

name	describe	Remark
0x00	Meaningless	
0x00	Meaningless	
0x00	Meaningless	
0x00	Meaningless	
YawL	Yaw angle Z low 8 bits	Yaw angle Z = ((YawH<<8)|YawL)/32768*180(°)

Yaw	Yaw angle Z high 8 bits	
V L	The lower 8 bits of the version number	Version number calculation formula: Version number = (VH <<8) | VL
VH	The high 8 bits of the version number	
SUM	Checksum	SUM=0x55+0x53+YawH+YawL+VL+VH

Write Format

Protocol Header	Protocol Header	register	Data lower 8 bits	Data high 8 bits
0xFF	0xAA	ADDR	DATAL[7:0]	DATAH[15:8]

- The following data are all in Hex code
- Each data is transmitted in sequence as low byte and high byte, and the two are combined into a signed short type data. For example, data DATA, where DATAL is the low byte and DATAH is the high byte. The conversion method is as follows: Assuming DATA is the actual data, DATAH is its high byte part, and DATAL is its low byte part, then: DATA=(short)((short) DATAH <<8| DATAL). It must be noted here that DATAH needs to be forced to be converted to a signed short type data before shifting, and the data type of DATA is also a signed short type, so that negative numbers can be represented.

Notice：

- All settings require unlocking register (KEY) FF AA 69 88 B5
- All settings must be saved after configuration (KEY) FF AA 00 00 00
- All setting instructions need to be delayed after execution

CALIYAW (Z-axis angle reset to zero)

Register Name: CALIYAW

Register address: 118 (0x76)

Read/write direction: R/W

Bit	NAME	FUNCTION
15:0	CALIYAW[15:0]	Set the Z axis to zero: 0(0x00): Z axis zero

Example: FF AA 76 00 00 (Z-axis angle returns to zero)

SAVE (Save/Restart/Restore to Factory)

Register Name: SAVE

Register address: 0 (0x00)

Read/write direction: R/W

Default value: 0x0000

Bit	NAME	FUNCTION
15:0	SAVE[15:0]	Save: 0x0000

		Restart: 0x00FF Factory Reset: 0x0001
Example: FF AA 00 FF 00 (restart)		

RRATE (output rate)

Register Name: RRATE Register address: 3 (0x03) Read/write direction: R/W Default value: 0x0006		
Bit	NAME	FUNCTION
15:4		
3:0	RRATE[3:0]	Set the output rate: 0001(0x01): 0.2Hz 0010(0x02): 0.5Hz 0011(0x03): 1Hz 0100(0x04): 2Hz 0101(0x05): 5Hz 0110(0x06): 10Hz 0111(0x07): 20Hz 1000(0x08): 50Hz

		1001(0x09): 100Hz 1011(0x0B): 200Hz 1011(0x0C): 500Hz
Example: FF AA 03 03 00 (set 1Hz output)		

BAUD (serial port baud rate)

Register name: BAUD

Register address: 4 (0x04)

Read/write direction: R/W

Default value: 0x0002

Bit	NAME	FUNCTION
15:4		
3:0	BAUD[3:0]	Set the serial port baud rate: 0001(0x01): 4800bps 0010(0x02): 9600bps 0011(0x03): 19200bps 0100(0x04): 38400bps 0101(0x05): 57600bps 0110(0x06): 115200bps 0111(0x07): 230400bps

Example: FF AA 04 06 00 (set the serial port baud rate to 115200)

IICADDR (device address)

Register Name: IICADDR

Register address: 26 (0x1A)

Read/write direction: R/W

Default value: 0x0050

Bit	NAME	FUNCTION
15:8		
7:0	IICADDR [7:0]	Set the device address for I2C use 0x01~0x7F

Example: FF AA 1A 02 00 (set the device address to 0x02)

LEDOFF (turn off the LED light)

Register Name: LEDOFF

Register address: 27 (0x1B)

Read/write direction: R/W

Default value: 0x0000

Bit	NAME	FUNCTION
15:1		

0	LEDOFF	1 : Turn off the LED light 0 : Turn on the LED light
Example: FF AA 1B 01 00 (turn off the LED light)		

READADDR (Read Register)

Register Name: READADDR

Register address: 39 (0x27)

Read/write direction: R/W

Default value: 0x00FF

Bit	NAME	FUNCTION
15:8		
7:0	READADDR [7:0]	Read register range: Please refer to "Register Table"

Example:

Send: FF AA 27 34 00 (read acceleration X axis 0x34)

Return: 55 5F AXL AXH AYL AYH AZL AZH GXL GXH SUM

For details, please refer to "Read Register Return Value" in the "Read Format" section.

VERSION

Register Name: VERSION

Register address: 46 (0x2E)

Read/write direction: R

Default value: None

Bit	NAME	FUNCTION
15:0	VERSION[15:0]	Different products have different version numbers

Example:

Send: FF AA 27 2E 00 (read version number, 0x27 means read, 0x2E is the version number register)

Return: 55 5F VL VH XX XX XX XX XX XX SUM

VERSION[15:0]=(short)(((short)VH<<8)|VL)

YYMM~MS (on-chip time)

Register name: YYMM~MS

Register address: 48~51 (0x30~0x33)

Read/write direction: R/W

Default value: 0x0000

Bit	NAME	FUNCTION
15:8	YYMM[15:8]	moon
7:0	YYMM[7:0]	Year

15:8	DDHH[15:8]	hour
7:0	DDHH[7:0]	day
15:8	MMSS[15:8]	Second
7:0	MMSS[7:0]	point
15:0	MS[15:0]	millisecond

Example:

FF AA 30 16 03 (set year and month 22-03)

FF AA 31 0C 09 (set date and time 12-09)

FF AA 32 1E 3A (set minutes and seconds 30:58)

FF AA 33 F4 01 (set milliseconds 500)

Example:

Send: FF AA 27 30 00 (read version number, 0x27 means read, 0x30 is year and month register)

Return: 55 5F YYMM[7:0] YYMM[15:8] DDHH[7:0] DDHH[15:8] MMSS[7:0] MMSS[15:8] MS[7:0] MS[15:8] SUM

GY~GZ (angular velocity)

Register name: GY~GZ

Register address: 56~57 (0x38~0x39)

Read/write direction: R

Default value: 0x0000		
Bit	NAME	FUNCTION
15:0	GY[15:0]	Angular velocity Y = GY[15:0]/32768*2000°/s【1】
15:0	GZ[15:0]	Angular velocity Z = GZ[15:0]/32768*2000°/s【2】

【1】Raw data of angular velocity Z

【2】The angular velocity Z obtained after the original data of angular velocity Z is calibrated

Yaw

Register Name: Yaw

Register address: 63 (0x3F)

Read/write direction: R

Default value: 0x0000

Bit	NAME	FUNCTION
15:0	Yaw[15:0]	Heading angle Z = Yaw[15:0]/32768*180°

WORKMODE (Z-axis operation mode)

Register Name: WORKMODE

Register address: 72 (0x48)

Read/write direction: R/W

Default value: 0x0000		
Bit	NAME	FUNCTION
15:4		
3:0	WORKMODE[3:0]	Set the Z-axis operation mode: 0000(0x00): Normal data mode 0001(0x01): Peak-to-peak value mode 0010(0x02): Request zero bias mode 0011(0x03): Calculate the scaling factor mode
Example: Send: FF AA 48 01 00 (automatically obtain zero offset)		

GYROPTP (Z-axis static peak-to-peak value)

Register Name: GYROPTP Register address: 74 (0x4A) Read/write direction: R/W Default value: 0x0000		
Bit	NAME	FUNCTION
15:0	GYROPTP[15:0]	Parameters used in calculating zero bias, automatically obtained by the sensor without setting
Write 0x01 to the "WORKMODE" register to enter the "Peak-to-Peak		

Mode". In this mode, the sensor automatically calculates the maximum and minimum Z-axis angular velocity within the time set by "GPTPTIME" and records them in "GYROPTP". This data will be used for zero bias calculation filtering in the "Zero Bias Mode".

Z-axis static peak-to-peak value = GYROPTP/1000 (°/s)

Example:

Send: FF AA 27 4A 00 (read the peak-to-peak value of the Z axis)

Return: 55 5F 64 00 XX XX XX XX XX XX SUM

0x0064=100, Z-axis static peak-to-peak value = 100/1000=0.1 (°/s)

GPTPTIME (Z-axis peak-to-peak acquisition time)

Register Name: GPTPTIME

Register address: 75 (0x4B)

Read/write direction: R/W

Default value: 0x000A

Bit	NAME	FUNCTION
15:0	GPTPTIME[15:0]	Calculate the peak-to-peak time, the default is 10S

Example: Send: FF AA 4B 0A 00 (set the Z-axis peak-to-peak value acquisition time to 10S)

After entering the "Peak-to-Peak Mode", the difference between the maximum and minimum Z-axis angular velocity within the " GPTPTIME " time is obtained

and stored in "GYROPTP". This data will be used for zero bias calculation and filtering in the "Bias Mode " .

GYROBAIS (Z-axis zero bias value)

Register name: GYROBAIS

Register address: 76 (0x4C)

Read/write direction: R/W

Default value: 0x0000

Bit	NAME	FUNCTION
15:0	GYROBAIS[15:0]	Horizontal gyro zero bias value, which can be obtained through "zero bias mode"

The Z-axis horizontal gyroscope has a certain zero bias value when it is stationary, and this zero bias value can be used to eliminate the angular velocity when it is stationary. The zero bias value can be automatically calculated by automatically obtaining the zero bias. Enter the "zero bias calculation mode" to automatically calculate the zero bias value based on the peak-to-peak value of "GYROPTP" and the zero bias acquisition time of "GBAISTIME".

Z-axis zero bias value = GYROBAIS/1000 (°/s)

Example:

Send: FF AA 27 4C 00 (read the peak-to-peak value of the Z axis)

Return: 55 5F 64 00 XX XX XX XX XX XX SUM

0x 0064 = 100, Z-axis static peak-to-peak value = 100/1000 = 0.1 (°/s)

GBAISTIME (Z-axis zero bias acquisition time)

Register name: GBAISTIME

Register address: 77 (0x4D)

Read/write direction: R/W

Default value: 0x000A

Bit	NAME	FUNCTION
15:0	GB AISTIME[15:0]	Time required for horizontal gyro zero bias calculation

Example: Send: FF AA 4D 0A 00 (set the Z-axis zero offset acquisition time to 10S)

The time required to obtain the Z-axis zero offset is used to obtain the zero offset value based on this time.

GSTATICTHRE (Z-axis static threshold)

Register Name: GSTATICTHRE

Register address: 78 (0x4E)

Read/write direction: R/W

Default value: 0x0032

Bit	NAME	FUNCTION
15:0	GSTATICTHRE [15:0]	the GSTATICTHRE [15:0], the stronger the anti-vibration performance and the larger the

		error. GSTATICTHRE [15:0] is, the weaker the anti-vibration performance is and the smaller the error is. Default value: 50

The Z-axis horizontal gyroscope has slight data jitter when it is stationary. This parameter can filter out these slight jitters. When the angular velocity is less than the " GSTATICTHRE " setting value and lasts for the " GSTATICTIME" setting time, it is considered stationary and the Z-axis angular velocity is zero. When the scene with jitter causes Z-axis accumulation, this parameter can be appropriately increased. When it is used in a scene with very slow and uniform rotation, this parameter can be appropriately reduced.

Z-axis zero offset value = GSTATICTHRE/1000 (°/s)

Example:

Send: FF AA 4E 64 00 ((Set Z axis still threshold 0.1°/s), 0x0064=100, 100/1000=0.1 (°/s))

GSTATICTIME (Z-axis stabilization time)

Register name: GSTATICTIME

Register address: 79 (0x4F)

Read/write direction: R/W

Default value: 0x0064

Bit	NAME	FUNCTION
15:0	GSTATICTIME	Z-axis judgment of stationary time

	[15:0]	

Z-axis static judgment time threshold. When the angular velocity is less than the value set by "GSTATICTHRE" and lasts for the time set by "GSTATICTIME", it is considered static. If you have high requirements for stabilization time, you can appropriately reduce this parameter. Reducing this parameter can speed up the stabilization time but may also increase the error.

Z-axis stabilization time = GSTATICTIME/1000 (s)

Example:

Send: FF AA 4F 32 00 ((Set Z axis stabilization time to 0.05s), 0x0032=50, 50/1000=0.05 (°))

PGSCALE (Z-axis calibration factor P)

Register name: PGSCALE

Register address: 80 (0x50)

Read/write direction: R/W

Default value: 0x2710

Bit	NAME	FUNCTION
15:0	PGSCALE [15:0]	Range: 0~20000 This parameter is written by the factory using a high-precision turntable. Please do not modify it.

There is an error in the Z-axis gyroscope measurement. This error is measured using a high-precision turntable at the factory and this parameter is written into the sensor. Do not modify this parameter unless necessary. This parameter can be automatically calculated in the "Calculation Factor Mode". After entering the

"Calculation Factor Mode", the sensor can be rotated by the angle set by " GSCALERANGE " to calculate the calibration factor.

Z-axis calibration factor P = PGSCALE/10000.0

Example:

Send: FF AA 27 50 00 (read Z-axis calibration factor P)

Return: 55 5F 74 27 XX XX XX XX XX XX SUM

0x2747 = 10100, read the Z-axis calibration factor P = 10100 /10000=1.01

GSCALERANGE (Z-axis angle calibration range)

Register Name: GSCALERANGE

Register address: 82 (0x52)

Read/write direction: R/W

Default value: 0x02D0

Bit	NAME	FUNCTION
15:0	GSCALERANGE [15:0]	When calibrating factors, you need to calibrate according to this parameter

Example:

Send: FF AA 52 68 01 ((Set Z-axis calibration angle 360), 0x0168 = 360)

The angle of rotation required in the Z-axis "scaling factor mode" is generally set to an integer multiple of 360°.

GYROCALITHR (gyro stationary threshold)

Register name: GYROCALITHR

Register address: 97 (0x61)

Read/write direction: R/W

Default value: 0x0000

Bit	NAME	FUNCTION
15:0	GYROCALITHR[15:0]	Set the gyroscope inactivity threshold: Gyro Gyro Stationary Threshold = GYROCALITHR[15:0]/1000(°/s)

Example:

FF AA 61 32 00 (set the gyroscope static threshold to 0.05 °/s, 0x0032 = 50, 50/1000 = 0.05 (°/s))

When the angular velocity changes less than 0.05 °/s and lasts for "GYROCALTIME", the sensor recognizes it as stationary and automatically resets the angular velocity less than 0.05 °/s to zero.

The setting rule of the gyroscope static threshold can be determined by reading the value of the "WERROR" register. The general setting rule is: GYROCALITHR=WERROR*1.2, unit: °/s

This register needs to be used in conjunction with the GYROCALTIME register.

GYROCALTIME (gyro automatic calibration time)

Register name: GYROCALTIME

Register address: 99 (0x63)

Read/write direction: R/W

Default value: 0x03E8

Bit	NAME	FUNCTION
15:0	GYROCALTIME[15:0]	Set the gyroscope automatic calibration time

Example: Set the gyroscope automatic calibration time to 500ms

FF AA 63 F4 01

When the angular velocity change is less than " GYROCALITHR " and lasts for 500ms, the sensor recognizes it as stationary and automatically resets the angular velocity less than 0.05 °/s to zero.

This register needs to be used in conjunction with the GYROCALITHR register.

WERROR (gyroscope change value)

Register Name: WERROR

Register address: 106 (0x6A)

Read/write direction: R

Default value: 0x0000

Bit	NAME	FUNCTION
15:0	WERROR[15:0]	Gyroscope change value = WERROR[15:0]/1000*180/3.1415926(°/s) When the sensor is stationary, the "GYROCALITHR"

		register can be set by changing this register

WZTIME (angular velocity continuous stationary time)

Register name: WZTIME

Register address: 110 (0x6E)

Read/write direction: R/W

Default value: 0x01F4

Bit	NAME	FUNCTION
15:0	WZTIME[15:0]	Angular velocity continuous stationary time

Example: Set the angular velocity to a continuous static time of 500ms

FF AA 6E F4 01

When the angular velocity is less than " WZSTATIC" and lasts for 500ms, the angular velocity output is 0 and the Z-axis heading angle is not integrated.

This register needs to be used in conjunction with the "WZSTATIC" register.

WZSTATIC (angular velocity integral threshold)

Register name: WZSTATIC

Register address: 111 (0x6F)

Read/write direction: R/W

Default value: 0x012C

Bit	NAME	FUNCTION
15:0	WZSTATIC[15:0]	Angular velocity integral threshold = WZSTATIC[15:0]/1000(°/s)

Example: Set the angular velocity integral threshold to 0.5 °/s

FF AA 6F F4 01

When the angular velocity is greater than 0.5 °/s, the Z-axis heading angle begins to integrate the acceleration

When the angular velocity is less than 0.5 °/s and lasts for the time set by the register "WZTIME", the angular velocity output is 0 and the Z-axis heading angle is not integrated.

This register needs to be used in conjunction with the "WZTIME" register.