美泰科技
MTMicrosystems

Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

MSG3000D
Multi-Axis Gyro Module
User Manual

Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

INDEX

美泰科技
MTMicrosystems
Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

1 FEATURES

- Miniature package
- Low noise
- Low bias instability
- Excellent performance in vibration and shock environments
- 3 axes offered in same package
- Electronically calibrated axis alignment
- Gyros based on MT MicroSystem Single-crystal silicon technology
- No intrinsic wear-out effects
- Insensitive to magnetic fields
- Digital interface, RS422
- Continuous self-diagnostics

2 GENERAL DESCRIPTION

MSG3000D is a MEMS inertial measurement unit consisting of 3 high accuracy MEMS-based gyros, power switching circuit, software of Unit, internal and external mechanical structure of energy dissipation structures and shock absorber in a miniature package.

Gyros are based on advanced MEMS Technology and wafer-level-package, which is highly stable and reliable. The MEMS chip, ASIC and temperature sensor are integrated and assembled in one ceramic package.

Fig.1-1 Image of MSG3000D

For gyroscopes，they are used to measure the palstance on three orthonormal axes of sensing carrier. Digital circuit and the software are used to compensation to the error of component and transfer the message back to the computer control loop installed on the missile through the RS422 interface. Each axis is factory-calibrated for bias, sensitivity and compensated for temperature effects to provide high-accuracy measurements in the temperature range -40°C to +85°C. The unit runs off a single +5V supply. Meanwhile, MSG3000D could not only self-check the operative condition of inertial component and digital circuit before launch but also continuous diagnose the operative condition of the product during operation.

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

3 Typical Applications

- Platform stabilization
- Navigation and dead reckoning
- Dynamic attitude measurement
- Ship motion measurement

4 DEFINITIONS AND ABBREVIATIONS USED IN DOCUMENT

4.1 Definitions

g_0= 9.79973 m/s^2 (standard gravity)

4.2 Abbreviations

Table4-1:Abbreviations

ABBREVIATION	FULL NAME
FS	Full-Scale
LF	Line Feed
tbd	to be defined
LSB	Least Significant Byte
MSB	Most Significant Byte
lsb	Least significant bit

美泰科技 MTMicrosystems
Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

5 ABSOLUTE MAXIMUM RATINGS

Stresses beyond those listed in Table 5-1 may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Table 5-1: Absolute maximum ratings

Parameter	Rating	Comment
Mechanical shock	1 500g/1ms half-sine	Any direction. Ref: MIL STD-883G
Storage temperature	-55°C to +90°C	
+5V to GND	4.5V to 5.5V	
RX+ or RX- to GND	-0.3V to 6V	
RX+ to RX-	±5V	
TX+ or TX- to GND	-0.3V to 6V	

6 SPECIFICATIONS

6.1 SYSTEM CHARACTERISTICS

Table 6-1:Operating conditions

Parameter	Conditions	Min	Nom	Max	Unit	Note
INPUT RANGE,ANGULAR RATE		±400			°/s	
POWER SUPPLY		4.5	5.0	5.5	V	
OPERATING TEMPERATURE		-40		+85	℃	

Table 6-2: Functional specifications, general

Parameter	Conditions	Min	Nom	Max	Unit	Note
POWER CONSUMPTION						
Power consumption			1	1.5	W	
TIMING						
Start-Up time after Power-On				1	s	1
Time to valid data	T=+25°C			2	s	2
RS422 Bit-Rate			921600			
Sample Rate			2000		Samples/s	
RS422 PROTOCOL						
Start Bit			1		bit	
Data Length			8		bits	
Parity			None			
Stop Bits			1		bit	

CHASSIS Isolation resistance chassis to GND(pin 15)	500V	20	MΩ	

Note 1: Time from Power-On to start of datagram transmissions (starting with part-number datagram)

Note 2: Time from Power-On to the reset of the Start-Up. During this period the output data should be regarded as non-valid.

Table 6-3: Functional specifications, gyros

Parameter	Conditions	Min	Nom	Max	Unit	Note
GYRO						
Full Scale(FS)			±400		°/s	
Resolution			24		bits	
			0.22		°/h	
Non-Linearity			200		ppm	
Bandwidth(-3dB)			250		Hz	
Sample Rate			2000		Samples/s	
Group Delay			3		ms	
Bias Range		-180	0	180	°/h	
Bias stability			10		°/h	
Bias error over temperature gradients	ΔT < ±1°C/min		5		°/h	
Bias Instability	Allan Variance @25°C		1		°/h	
Angular Random Walk	Allan Variance @25°C		0.15		°/√hr	
Linear Acceleration Effect						
	With g-compensation		0.005		°/s/g	
Misalignment			1		mrad	

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

6.2 TYPICAL PERFORMANCE CHARACTERISTICS

6.2.1 Root Allan Variance of gyro

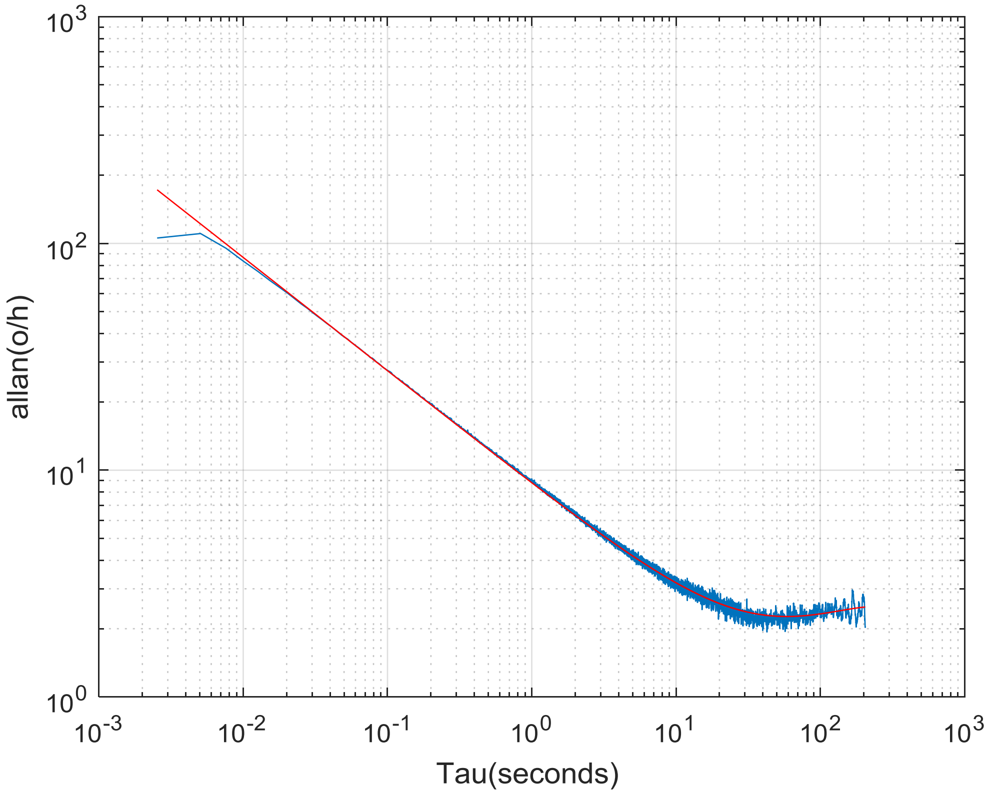


Figure 6-1-1: Typical Allan-Variance of gyro-X (400°/s gyro)

Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

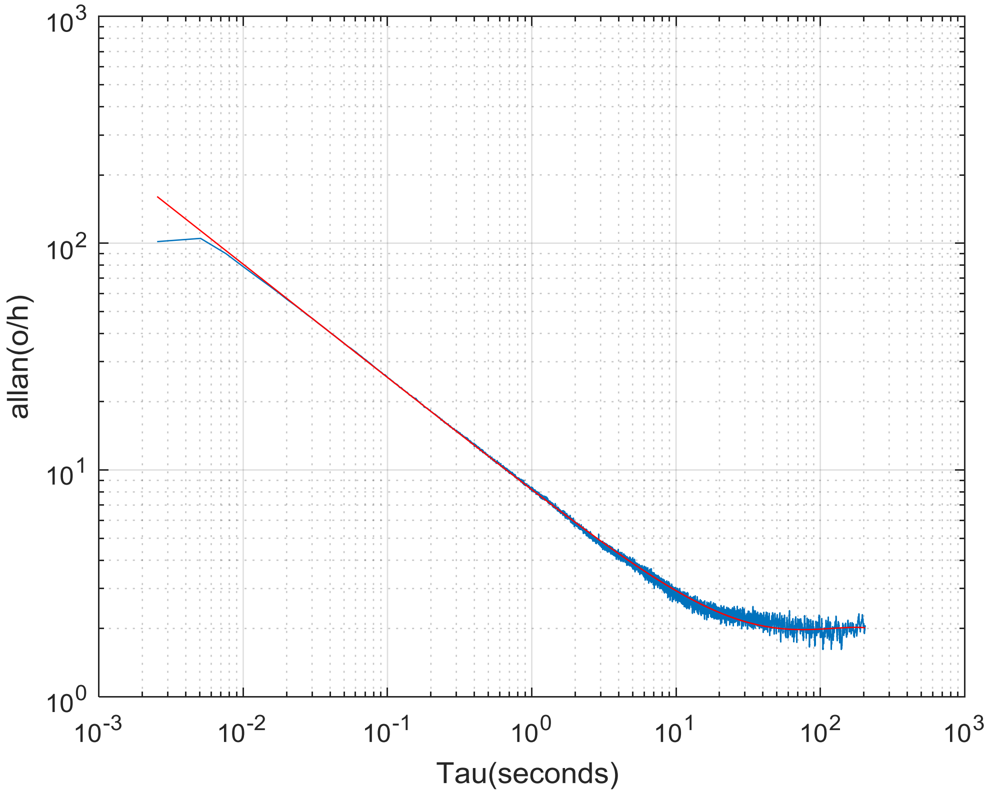


Figure 6-1-2: Typical Allan-Variance of gyro-Y (400°/s gyro)

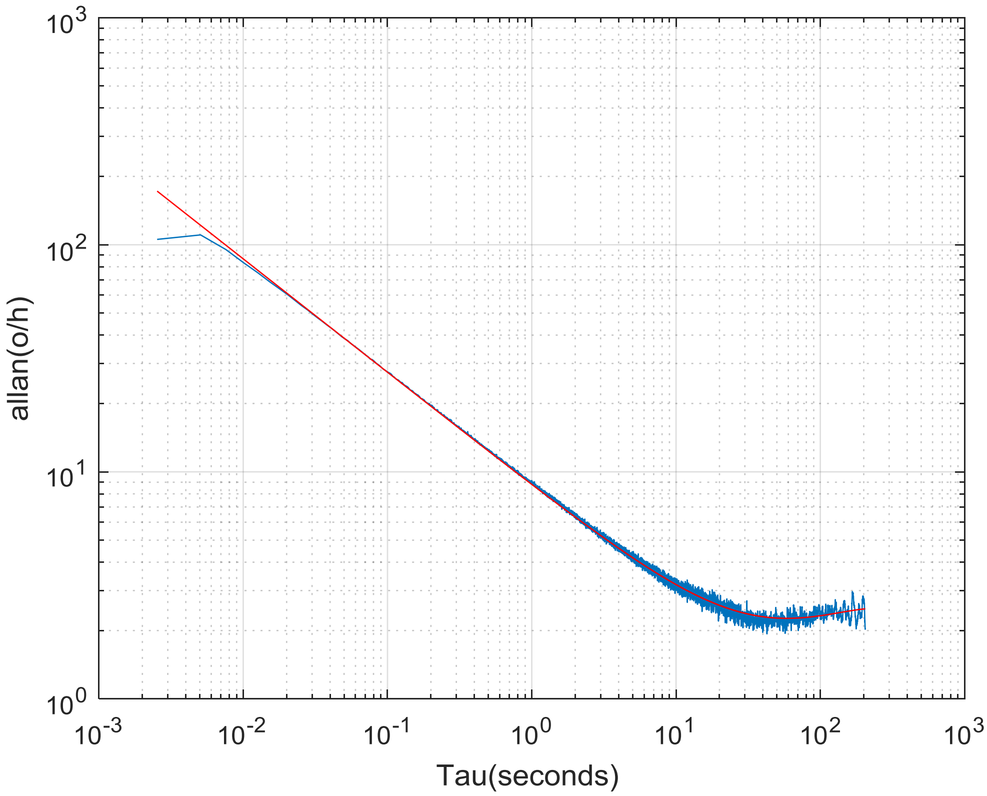


Figure 6-1-3: Typical Allan-Variance of gyro-Z (400°/s gyro)

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

6.2.2 Initial bias drift of gyro

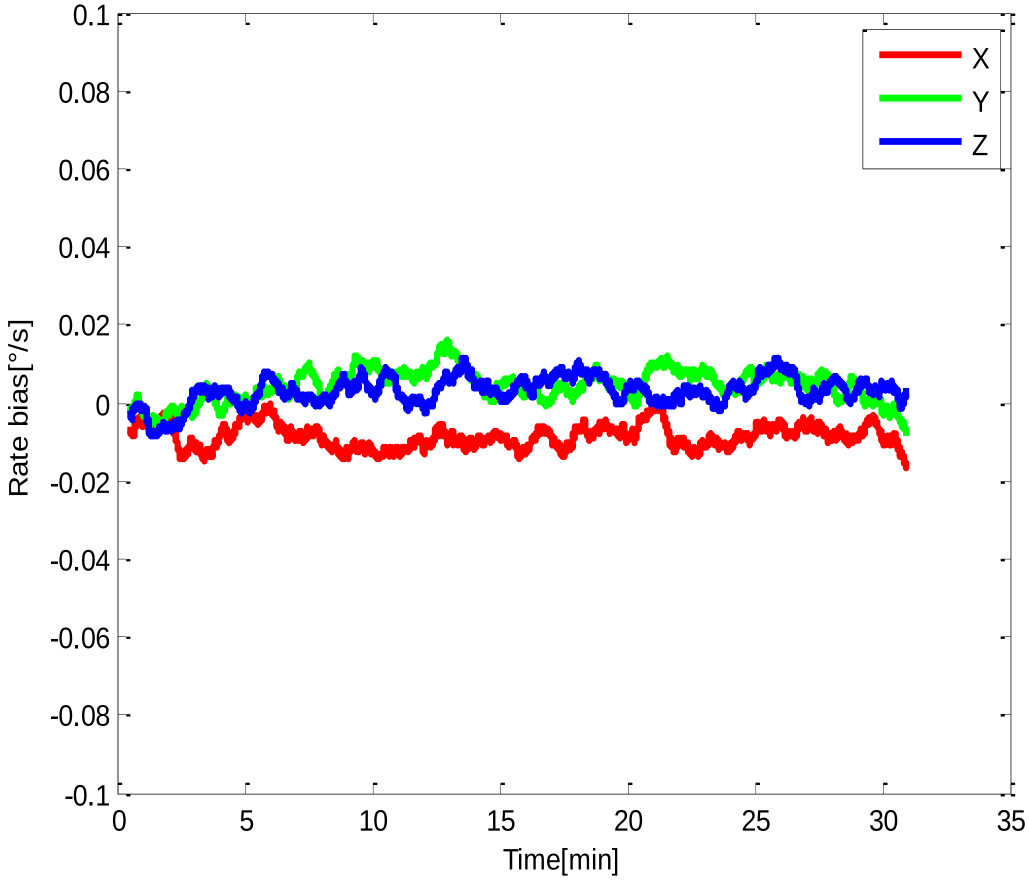
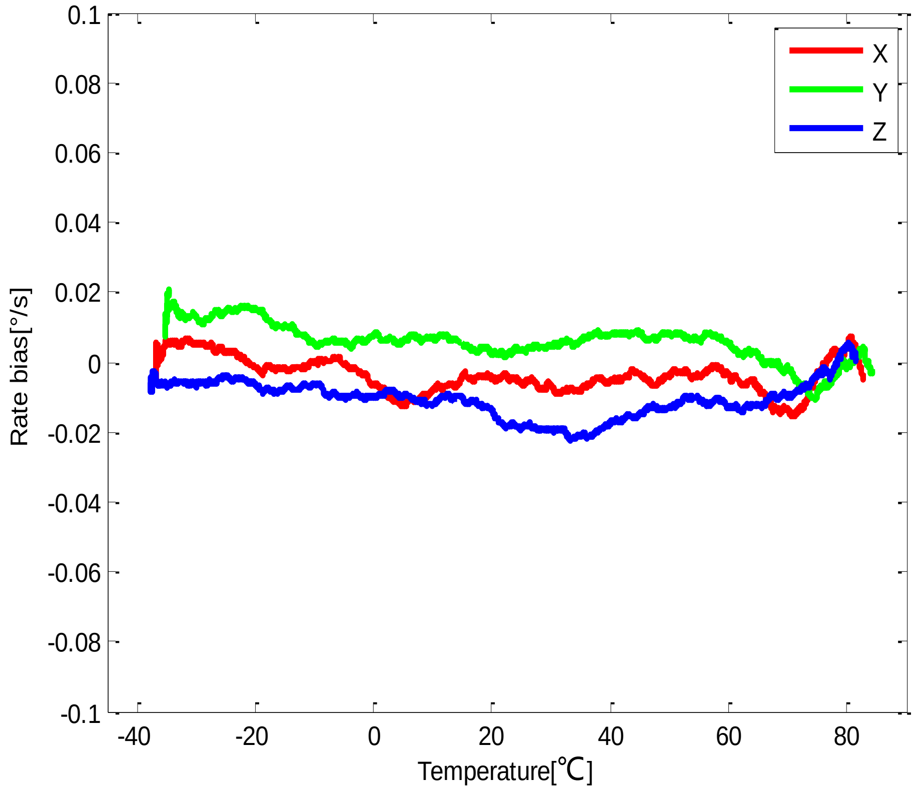


Figure 6-2: Typical normalized initial bias drift of gyro (400°/s gyro)

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

6.2.3 Bias drift over temperature



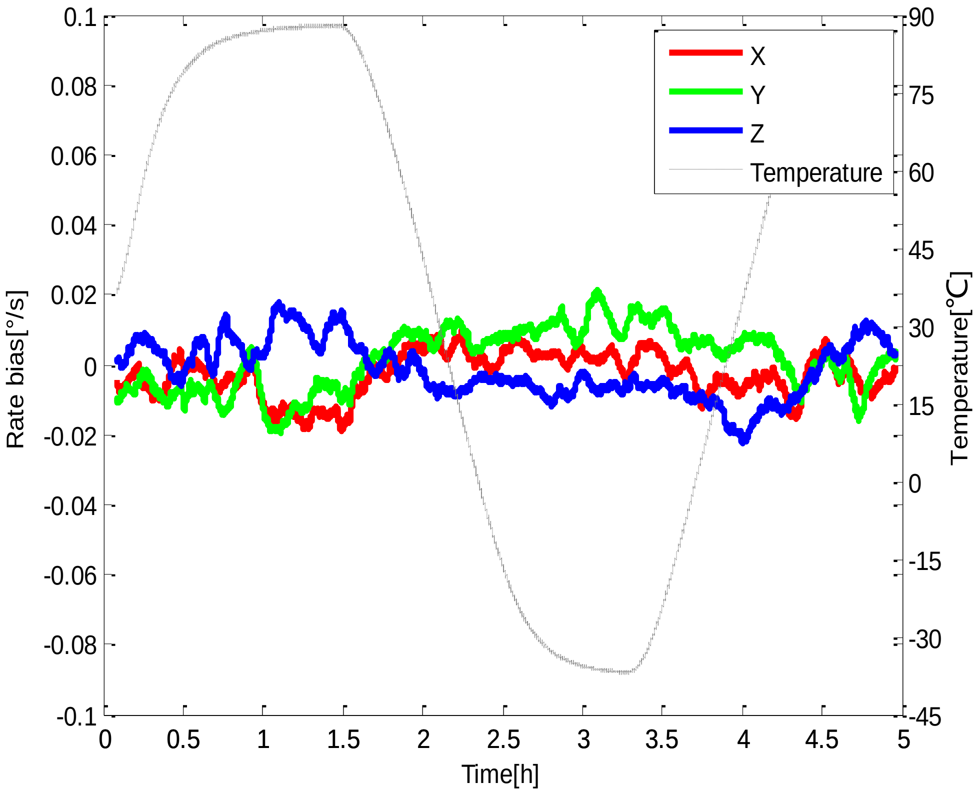


Figure 6-3: Typical Bias drift over temperature (400°/s gyro)

6.3 Normal Mode datagram

Table 6-4: Specification of the Normal Mode

Byte#	Bit#								Specification
	7	6	5	4	3	2	1	0	
0	1	0	0	1	1	0	0	1	Normal Mode datagram identifier for Normal Mode datagram with full content.
1	Gx23	Gx22	Gx21	Gx20	Gx19	Gx18	Gx17	Gx16	X-axis gyro output, ref. section 8.1.1 for conversion to units
2	Gx15	Gx14	Gx13	Gx12	G11	Gx10	Gx9	Gx8	
3	Gx7	Gx6	Gx5	Gx4	Gx3	Gx2	Gx1	Gx0	
4	Gy23	Gy22	Gy21	Gy20	Gy19	Gy18	Gy17	Gy16	Y-axis gyro output, ref. section 8.1.1 for conversion to units
5	Gy15	Gy14	Gy13	Gy12	Gy11	Gy10	Gy9	Gy8	
6	Gy7	Gy6	Gy5	Gy4	Gy3	Gy2	Gy1	Gy0	
7	Gz23	Gz22	Gz21	Gz20	Gz19	Gz18	Gz17	Gz16	Z-axis gyro output, ref. section 8.1.1 for conversion to units
8	Gz15	Gz14	Gz13	Gz12	Gz11	Gz10	Gz9	Gz8	
9	Gz7	Gz6	Gz5	Gz4	Gz3	Gz2	Gz1	Gz0	

10	Gs7	Gs6	Gs5	Gs4	Gs3	Gs2	Gs1	Gs0	STATUS byte for gyro measurements, ref.Table 6-5
11	GTx15	GTx14	GTx13	GTx12	GTx11	GTx10	GTx9	GTx8	X-axis gyro temperature data, ref. section 8.1.2for conversion to units
12	GTx7	GTx6	GTx5	GTx4	GTx3	GTx2	GTx1	GTx0	
13	Gty15	Gty14	Gty13	Gty12	Gty11	Gty10	Gty9	Gty8	Y-axis gyro temperature data, ref. section 8.1.2 for conversion to units
14	Gty7	Gty6	Gty5	Gty4	Gty3	Gty2	Gty1	Gty0	
15	GTz15	GTz14	GTz13	GTz12	GTz11	GTz10	GTz9	GTz8	Z-axis gyro temperature data, ref. section 8.1.2 for conversion to units
16	GTz7	GTz6	GTz5	GTz4	GTz3	GTz2	GTz1	GTz0	
17	n7	n6	n5	n4	n3	n2	n1	n0	Counter, ref.section 8.1.3
18	c7	c6	c5	c4	c3	c2	c1	c0	Cyclic Redundancy Check is performed on all preceding bytes and is generated from the polynomial: x8 + x2 + x + 1, seed = 0xFF

6.4 Cyclic Redundancy Check

At the end of all datagrams is a 8-bit check. The check enables the user to detect errors in the transfer of data from MSG3000D.

```
crc8_tab[256]={0x0,0x7,0xe,0x9,0x1c,0x1b,0x12,0x15,
               0x38,0x3f,0x36,0x31,0x24,0x23,0x2a,0x2d,
               0x70,0x77,0x7e,0x79,0x6c,0x6b,0x62,0x65,
               0x48,0x4f,0x46,0x41,0x54,0x53,0x5a,0x5d,
               0xe0,0xe7,0xee,0xe9,0xfc,0xfb,0xf2,0xf5,
               0xd8,0xdf,0xd6,0xd1,0xc4,0xc3,0xca,0xcd,
               0x90,0x97,0x9e,0x99,0x8c,0x8b,0x82,0x85,
               0xa8,0xaf,0xa6,0xa1,0xb4,0xb3,0xba,0xbd,
               0xc7,0xc0,0xc9,0xce,0xdb,0xdc,0xd5,0xd2,
               0xff,0xf8,0xf1,0xf6,0xe3,0xe4,0xed,0xea,
               0xb7,0xb0,0xb9,0xbe,0xab,0xac,0xa5,0xa2,
               0x8f,0x88,0x81,0x86,0x93,0x94,0x9d,0x9a,
               0x27,0x20,0x29,0x2e,0x3b,0x3c,0x35,0x32,
               0x1f,0x18,0x11,0x16,0x3,0x4,0xd,0xa,
               0x57,0x50,0x59,0x5e,0x4b,0x4c,0x45,0x42,
               0x6f,0x68,0x61,0x66,0x73,0x74,0x7d,0x7a,
               0x89,0x8e,0x87,0x80,0x95,0x92,0x9b,0x9c,
               0xb1,0xb6,0xbf,0xb8,0xad,0xaa,0xa3,0xa4,
               0xf9,0xfe,0xf7,0xf0,0xe5,0xe2,0xeb,0xec,
               0xc1,0xc6,0xcf,0xc8,0xdd,0xda,0xd3,0xd4,
               0x69,0x6e,0x67,0x60,0x75,0x72,0x7b,0x7c,
               0x51,0x56,0x5f,0x58,0x4d,0x4a,0x43,0x44,
               0x19,0x1e,0x17,0x10,0x5,0x2,0xb,0xc,
               0x21,0x26,0x2f,0x28,0x3d,0x3a,0x33,0x34,
               0x4e,0x49,0x40,0x47,0x52,0x55,0x5c,0x5b,
               0x76,0x71,0x78,0x7f,0x6a,0x6d,0x64,0x63,
               0x3e,0x39,0x30,0x37,0x22,0x25,0x2c,0x2b,
               0x6,0x1,0x8,0xf,0x1a,0x1d,0x14,0x13,
               0xae,0xa9,0xa0,0xa7,0xb2,0xb5,0xbc,0xbb,
               0x96,0x91,0x98,0x9f,0x8a,0x8d,0x84,0x83,
               0xde,0xd9,0xd0,0xd7,0xc2,0xc5,0xcc,0xcb,
               0xe6,0xe1,0xe8,0xef,0xfa,0xfd,0xf4,0xf3};
```

Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

6.5 Status byte

Table 6-5: Interpretation of bits in STATUS byte

Bit	STATUS bit information	Comment
7	0=OK, 1=System integrity error	
6	0=OK, 1=Start-Up	
5	0=OK, 1=Outside operating conditions	
4	0=OK, 1=Overload	Bits 0-2 will flag the overload channel(s)
3	0=OK, 1=Error in measurement-channel	Bits 0-2 will flag the error channel(s)
2	0=OK, 1=Z-channel	
1	0=OK, 1=Y-channel	
0	0=OK, 1=X-channel	

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

7 MECHANICAL

Table 7-1: Mechanical specifications

Parameter	Conditions	Min Nom Max	Unit	NOTE
HOUSING MATERIAL		Aluminium Alloy 6082-T6,DIN EN 754-2		
SURFACE TREATMENT Passivation		Surtec 650		
WEIGHT		70	grams	
VOLUME		32.6	ccm	
		1.99	cu in	
CONNECTOR				
Type		J30J-15ZKP		
Number of pins		15		
Contact type female		female		
PLUG				
Proposed plug to fit connector		Axon MDA 2 15		
Proposed cover to fit plug	For best EMI performance	Axon micro-D EMI back shell		
FIXATION BOLTS		ISO 4762 / DIN 912		
Recommended torque Steel base		3.5	Nm	
	Aluminium base	3.0	Nm	

7.1 Mechanical dimensions

All dimensions are in mm.

Mechanical Drawing

Table 7-2: Mechanical dimensions of MSG3000D

Symbol	Dimension(mm)	Symbol	Dimension(mm)
A	21.50±0.30	*G*	7.60±0.20
A1	7.60±0.20	*P1*	4.20±0.15
A2	5.80±0.15	*q1*	35.90±0.15
D	44.80±0.30	*q2*	29.30±0.15
E	38.60±0.30	*Z*	4.65±0.15

Figure 7-1: Pin configuration as seen from front of MSG3000D

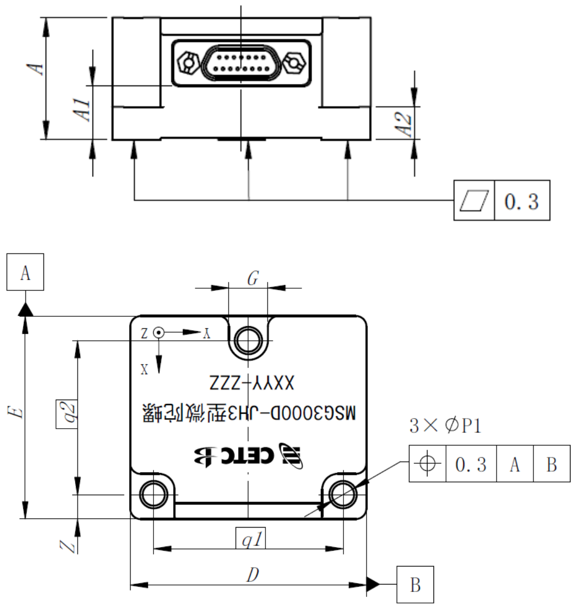


Figure 7-2: Mechanical dimensions

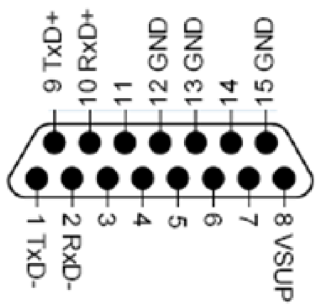


Table 7-2: Pin descriptions

Add: 21， Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

7.2 Pin configuration

The output connector is J30J-15ZKP, the Electric connection definition is as follows:

Table 7-3: Electric connection

ID	Definition	Note
1	TX-	RS422 Transmit Negative
2	RX-	RS422 Transmit Negative
3	Blank	N/A
4	Blank	N/A
5	Blank	N/A
6	Blank	N/A
7	Blank	N/A
8	+5V	Power
9	TX+	RS422 Transmit Positive
10	RX+	RS422 Receive Positive
11	Blank	N/A
12	GND	
13	GND	
14	Blank	N/A
15	GND	

7.3 Definition of axes

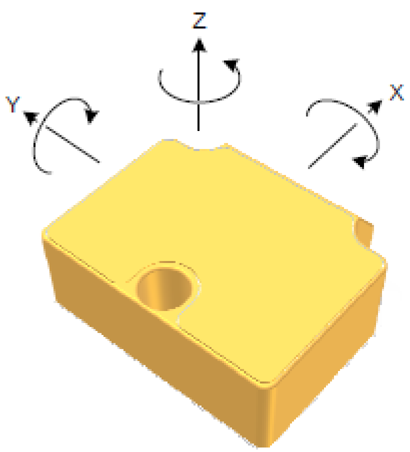


Figure 7-3: Definition of axes

Add: 21, Changsheng Street, Shijiazhuang 050299 CHINA
Tel: +86 311 83933866 Fax: +86 311 83933867
www.mtmems.com sales@mtmems.com

8 BASIC OPERATION

MSG3000D is very simple to use. The unit will start performing measurements and transmit the results over the RS422 interface without any need for additional signaling or set-up after power-on. Figure 8-1 shows the simplest connection set-up for MSG3000D.

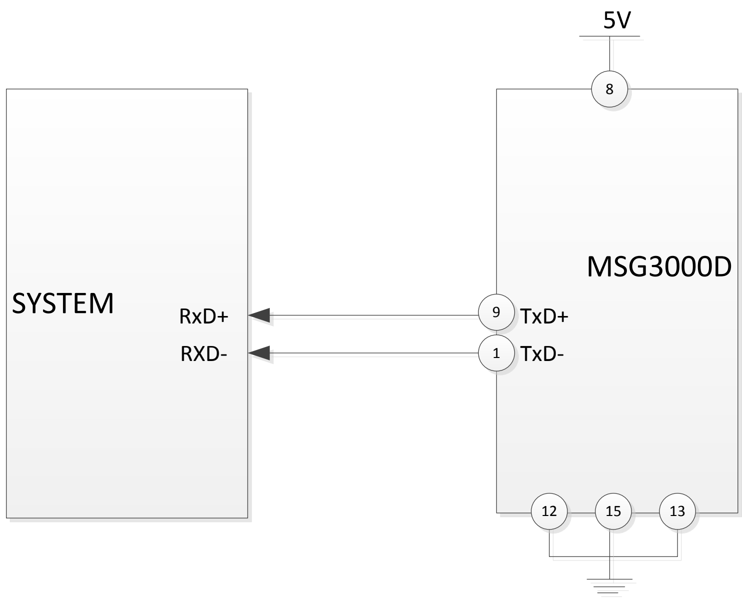


Figure 8-1: Full Function Electrical Connection Diagram

MSG3000D will constantly measure the available sensor channels at the configured sample rate. MSG3000D will continue to transmit data regardless of any errors reported in the STATUS-bytes. Hence the content of the STATUS-byte should continuously be examined.

8.1 Data output options and interpretation

8.1.1 Gyro output unit = Angular Rate

In the case of MSG3000D being configured to output angular rate, Following equation and figure show how to convert to [°/s]. Please note that the output data is represented as two's complement.

Equation 1: Converting output to [°/s]:

$$Output[°/s] = \frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^{8} + AR_3}{2^{14}}$$

where AR_1 is the most significant byte of the 24bit output
AR_2 is the middle byte of the 24bit output
AR_3 is the least significant byte of the 24bit output

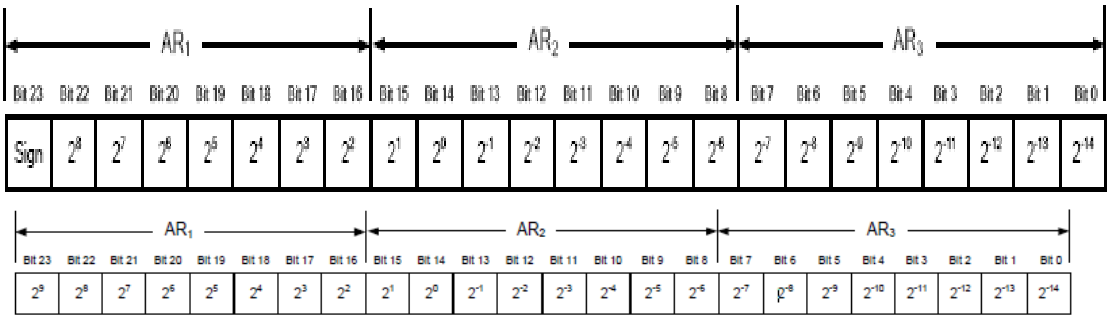


Figure 8-2: Converting output bytes to [°/s]

8.1.2 Temperature

Temperature data for each axis is available in certain datagrams.

Following equation and figure show how to convert to [°C]. Please note that the output data is represented as two's complement.

Equation 2: Converting temperature data to [°C]

$$Output[℃] = \frac{T_1 \cdot 2^8 + T_2}{2^8}$$

where T1 is the most significant byte of the 16bit output

T2 is the least significant byte of the 16bit output

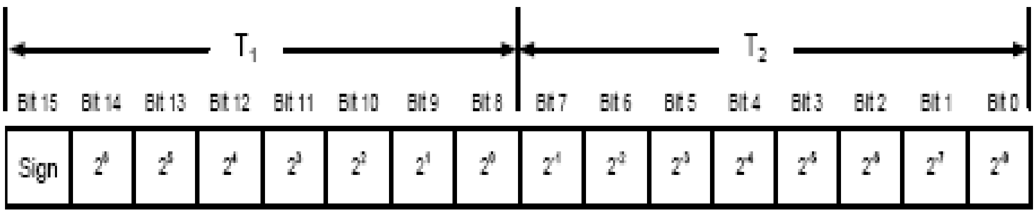


Figure 8-3: Converting temperature data to [°C]

8.1.3 Counter

Counter is continuously counting the internal samples (2000 samples/s). Counter is an un-signed single byte taking values in the interval [0 , 255]. The counter will naturally wrap-around with no error-message indication in the Status-byte.

9 MARKING

Figure 9-1: Example of marking of MSG3000D