IMU6-6 High Precision MEMS Inertial Measurement Unit Product instruction manual

This product manual is the main reference document for the use and operation of IMU6-6 high-precision micro-electromechanical inertial measurement unit (hereinafter referred to as IMU6-6).

1 Product features and technical parameters

1.1 Composition and function

IMU6-6 is composed of a three-axis high-precision MEMS gyroscope chip, a three-axis MEMS accelerometer chip, a temperature sensor, a signal processing board, a structure and all-factor compensation (including temperature compensation, installation misalignment angle compensation, nonlinear compensation, etc.) software, and is used to measure the three-axis angle of the carrier.Rate, three-axis acceleration and three-axis tilt angle, and output the gyro and accelerometer data after error compensation through the RS-422 serial port according to the agreed communication protocol.

1.2 Main technical parameters

1.2.1 Specifications of MEMS Gyroscope

Parameter	Unit	Test conditions	IMU6-6	
Measuring range	°/s	Optional	±500	±500
Zero-bias instability	°/h	Allan variance	0.03	0.1
Zero bias stability	°/h	10 s smoothing, RMS, ambient	0.5	1
Zero bias variation at full temperature	°/h	10 s smoothing, RMS, temperature rate 1 °C/min	1.5	3
Random walk	°/√h	Allan variance	0.02	0.05
Zero-bias repeatability	°/h	Q = 6, normal temperature	0.3	1
Zero bias acceleration sensitivity	°/h/g	Test at ± 1 G	1	1
Resolution	°/h		0.5	1
Output noise	°/s	Peak (half peak, STD * 3)	0.05	0.15
Scale factor	ppm	Normal temperature	300	

nonlinearity				
Scale factor repeatability	ppm	**Q = 3, normal temperature**	300	
Cross coupling	%	**Normal temperature**	0.1	
Bandwidth	Hz		100	250

1.2.2 MEMS Accelerometer Specifications

Parameter	Unit	Test conditions	IMU6-6			
Measuring range	g	**Optional**	±10	±30	±50	±80
Zero bias stability	mg	**1s smooth, RMS, normal temperature**	0.1	0.5	1	2
Zero bias variation at full temperature	mg	**10 s smoothing, RMS, temperature rate 1 ℃/min**	1	3	5	10
Zero-bias repeatability	mg	**Q = 6, normal temperature**	0.3	0.5	1	2
Resolution	mg		0.1	0.1	0.1	0.1
Scale factor nonlinearity	ppm	**Normal temperature**	500			
Scale factor repeatability	ppm	**Q = 3, normal temperature**	500			
Cross coupling	%	**Normal temperature**	0.2			
Bandwidth	Hz		150			

1.2.3 Electrical characteristics

Parameter	Unit	IMU6-6
Voltage	**V**	**+5±0.5**
Starting current	**mA**	**＜400**
Steady-state power consumption	**W**	**＜1.2**
Ripple	**mV**	**100**

1.2.4 Environmental adaptability

Parameter	Unit	IMU6-6
Operating temperature	℃	-45~85
Storage temperature	℃	-55~105

1.2.5 Other

Parameter	Unit	IMU6-6
Weight	g	120
Start time	s	1

2 Space coordinate system

2.1 Right hand rule principle one

IMU6-6 contains three axial spatial coordinate systems, namely X, Y and Z. The X axis points to the top surface of IMU6-6, the Y axis points to the direction of the electrical connection interface, and the Z axis points to the right side, as shown in Figure 2-1.

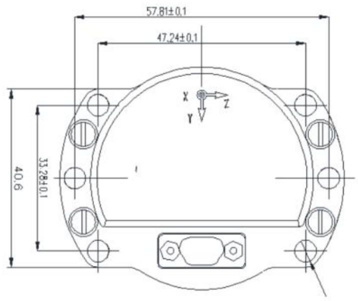


Figure 2-1 IMU6-6 Space Coordinate System

The installation of IMU6-6 shall be matched with the axial direction of the coordinate system, otherwise the measured angular velocity data will be inaccurate. The axis of the coordinate system can be quickly assigned and determined by following the "right-hand rule principle 1". Stretch out the right hand and spread out the thumb, index finger and middle finger respectively. The direction of the thumb is the X axis, the direction of the index finger is the Y axis, and the direction of the middle finger is the Z axis, as shown in Figure 2-2.

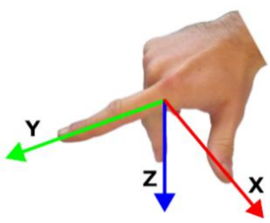


Figure 2-2 Right Hand Rule Principle 1

2.2 Right hand rule principle two

The three-degree-of-freedom gyroscope in IMU6-6 can measure the angular velocity in three directions. The direction of the angular velocity of the axial rotation of the coordinate axis can be quickly determined by following the'right-hand rule principle 2 '. Stretch out the right hand and unfold the thumb. The direction of the thumb is the axial direction, and the direction of the other four fingers is the direction of the angular velocity of the axial rotation of the thumb, as shown in Figure 2-3.

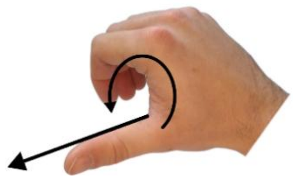


Figure 2-3 Right Hand Rule Principle 2

3 Overall dimension, lettering and installation

3.1 overall dimensions

See Figure 3-1 for the outline drawing of IMU6-6.

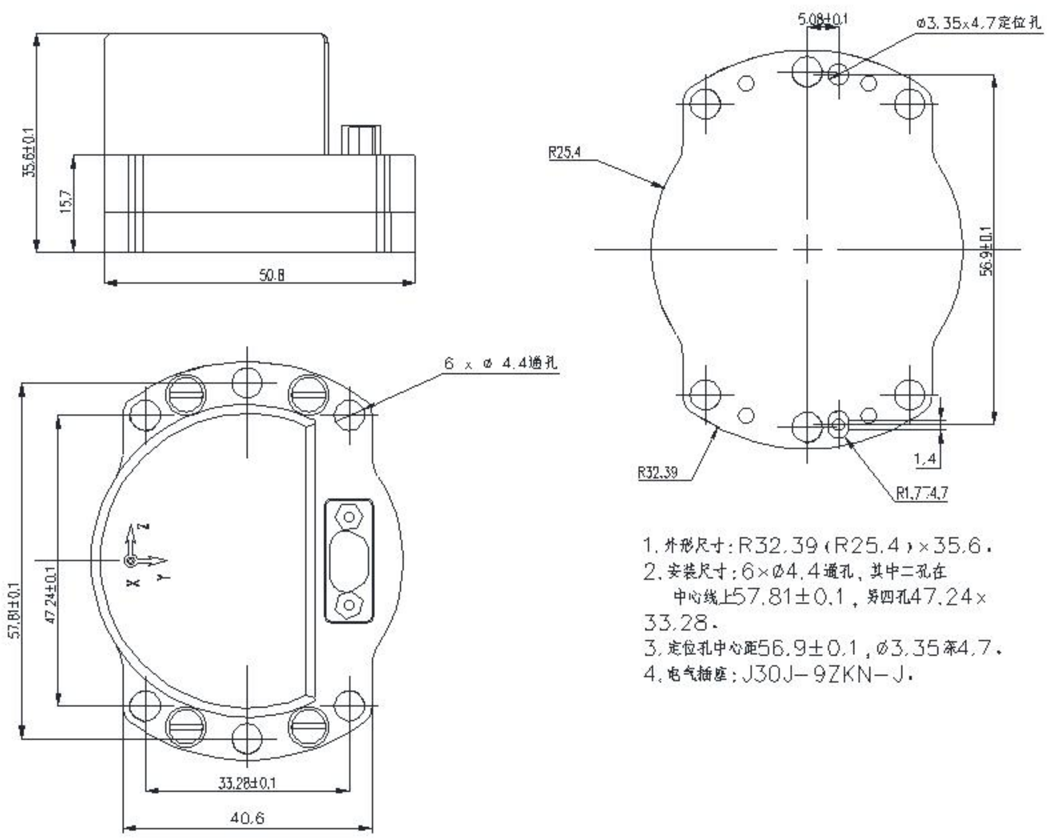


Figure 3-1 IMU6-6 Outline Drawing

In the drawing, "IMU6-6" is the product code "and" XX-XXX "is the product number.

IMU6-6IMU6-6 has two φ 3.35 deep 4.7 positioning holes, and the center distance of the positioning hole is 56.9 ± 0.1; six φ 4.4 through holes, of which two holes are 57.81 ± 0.1 on the center line, and the other four holes are 47.24 × 33.28. When installing, position first, and then install through the hole.

3.2 Lettering requirements

The default requirements for lettering on the product housing are as follows:

As shown in Figure 3-1 Product Outline Drawing, identify: product code, name, number, coordinate axis "X, Y, Z". Where "XX-XXX" is the product number.

4 Electrical characteristics

The model of the external electrical connector of IMU6-6 is J30J-9ZKN-J, and the model of the connector connected with IMU6-6 is J30J-9 TJ. See the following Table 4-1 for the specific distribution of the product connector nodes, and see Figure 4-1 for the connector node diagram.

Table 4-1 J30J-9ZKN-J Contact Distribution

Node number	Definition	Use
1	Tx+	Product output RS422
2	Tx-	
3	Rx+	The product receives RS422
4	Rx-	
5	GND	Power ground
6	+5V	Power supply positive
7	EXT	External trigger, 3.3 V TTL level, falling edge active
8	Data sync output	Synchronous output RS422
9	Data sync output	Synchronous output RS422

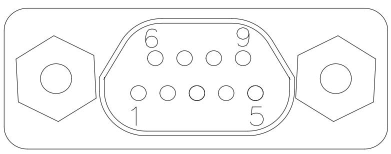
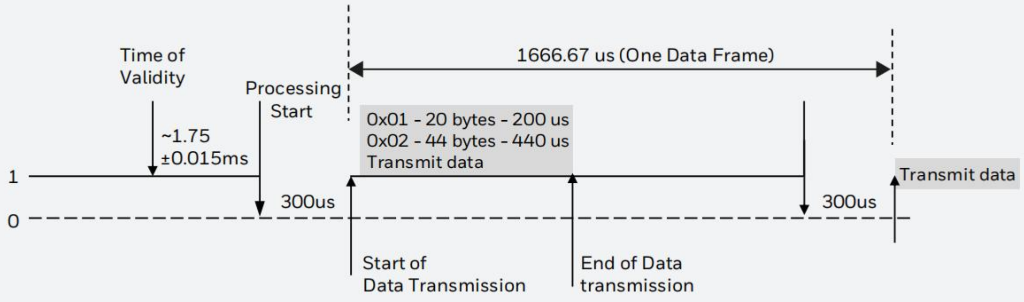


Figure 4-1 J30J-9ZK Node Distribution Diagram

Figure 2. Data Synchronization Signal Timing



5 Communication interface

5.1 Communication interface

It communicates with the processing circuit unit through the serial communication interface and adopts the RS-422 standard. Both the transmission baud rate and the data update rate can be configured by software.

Communication protocol: baud rate 921 600bps, 8 data bits, 1stop bit, no check bit, 0xA5 data frame, update rate 1000Hz.

5.2 Data frame format

IMU6-6 sends data frames in each cycle, and the data frame format is shown in the following table.

Table 5-2 Data Frame Format of 'Gyro + Add Table + Temperature'

Serial number	Parameter name	Effective range	Byte	Scale	Remark
1	Frame header	0xA5	1	——	Packet header
2	X-axis angular velocity	[-200，200]	3	2^{-14}	Unit °/s, first high and then low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
3	Y-axis angular velocity	[-200，200]	3	2^{-14}	Unit °/s, first high and then low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.
4	Z-axis angular velocity	[-200，200]	3	2^{-14}	Unit °/s, first high and then low, the most significant bit of the first byte is the sign bit. See Note 1 for the specific algorithm.

5	Gyro status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
6	X-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
7	Y-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
8	Z-axis acceleration	[-10，10]	3	2^{-19}	Unit: G, first high and then low, the most significant bit of the first byte is the sign bit. See Note 2 for the specific algorithm.
		[-30，30]		2^{-18}	
		[-50，50]		2^{-17}	
9	Add table status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
10	X-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
11	Y-axis gyro temperature	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
12	Temperature of Z-axis gyroscope	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
13	Gyro Thermometer Status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
14	X-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
15	Y-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
16	Z-axis plus surface temperature	[-128，128]	2	2^{-8}	Unit: °C, from high to low, the most significant bit of the first byte is the sign bit. See Note 4 for the specific algorithm.
17	Add thermometer status	——	1	——	All zeros are normal. See Table 5-10 for specific definitions.
18	Frame counter	[0，255]	1	1	0-255 continuous count
19	Delay		2		Unit: us, first high and then low, the most

					significant bit of the first byte is the sign bit. See Note 5 for the specific algorithm.
20	CRC32	——	4	——	CRC32 verification, see instruction 6

Explain

1) Gyro angular velocity output [°/s] = $\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^{14}}$ See Figure 5-1 for data bit format;

Among AR_1 Outputting the high eight bits of the three bytes for the angular velocity of each axis of the gyroscope;

AR_2 Outputting the middle eight bits of the three bytes for the angular velocity of each axis of the gyroscope;

AR_3 Outputs the lower eight bits of the three bytes for the angular velocity of each axis of the gyro.

AR_1								AR_2								AR_3							
Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16	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	Bit 0
2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}

Figure 5-1 Converting the Gyro Angular Velocity Output to [°/s]

2) Accelerometer speed output [G] =$\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^X}$;

Among AR_1 Outputs the upper eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_2 Outputs the middle eight bits of the three bytes for the angular velocity of each axis of the accelerometer;

AR_3 Outputs the lower eight bits of the three bytes for the angular velocity of each axis of the accelerometer.

X is the tabulated scale index, and the 10g, 30g, and 50g tabulations correspond to X being the 19,18 and 17.

3) Tilt speed output [G] =$\frac{AR_1 \cdot 2^{16} + AR_2 \cdot 2^8 + AR_3}{2^{22}}$;

Among AR_1 Outputs the upper eight bits of the three bytes for the angular velocity of each axis of the tilt angle;

AR_2 The middle eight bit of that three bytes are output for the angular velocity of each axis of the tilt angle;

AR_3 The lower eight bits of the three bytes are output for the angular velocity of each axis of the tilt angle.

4) Temperature output [°C] $= \frac{T_1 \cdot 2^8 + T_2}{2^8}$? See Figure 5-2 for data bit format.

Among T_1 Outputs the upper eight bits of the two bytes for each axis temperature;

T_2 Outputs the lower eight bits of the two bytes for each axis temperature.

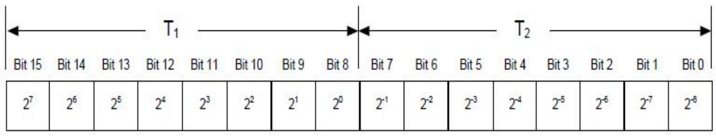


Figure 5-2 Converting Temperature Output to [°C]

5) Delay time output [us] $= T_1 \cdot 2^8 + T_2$

Wherein, T1 is the high eight bits in the two bytes of the delay time output;

T2 is the lower eight bits of the two bytes of the delay time output.

6) CRC check method

The CRC uses the standard CRC-32 polynomial:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

seed = 0xFFFFFFFF

See Appendix B for a list of table and table lookup function codes generated from this polynomial.

5.3 Self-check function and real-time output function of working status

IMU6-6 has the functions of self-test and real-time output of working status. The data frame contains a byte indicating the status, and the real-time output of product working status information is started after the power-on startup is completed. The status bits are defined in Table 5-10.

Table 5-10 Product Status Bit Definitions

Bit	Definition
7	0 = normal, 1 = system-wide abnormal
6	0 = normal, 1 = starting
5	0 = normal, 1 = abnormal external environment
4	0 = normal, 1 = three axes out of service condition
3	0 = normal, 1 = error in three-axis output
2	0 = OK, 1 = Z axis out of use condition or error
1	0 = OK, 1 = Y axis out of use condition or error
0	0 = OK, 1 = X axis out of use condition or error

6 Functional testing

6.1 Test equipment and instrumentation required

The equipment and instruments required for IMU6-6 test include: DC regulated power supply, computer, turntable, high and low temperature box, test tooling and test cable.

6.2 Functional testing

IMU6-6 is in a static state, and the DC regulated power supply is used to supply power to the product. The power supply requirements meet the requirements of 1.2. The specific connection mode of the product is shown in Figure 6-1. Data is received according to the communication protocol, and the angular velocity output of the product is received and displayed by the upper computer receiving software.

Rotate the gyro assembly in the X, Y and Z directions respectively (input by the turntable if conditions permit, and rotate by hand if no conditions permit), and the angular velocity output of the corresponding axis can be monitored as the positive angular rate. Rotate the product reversely around X, Y and Z respectively, and the angular velocity output of the corresponding axis can be monitored to be a negative angular velocity. It indicates that the angular velocity output polarity of the product is correct. The three angular rate values at the output of the product shall be in the vicinity of 0 deg/s under stationary conditions.

The acceleration output of the corresponding axis can be monitored to be 1G by overtaking X, Y and Z in the forward direction respectively. Under static conditions, the acceleration of the product is about 0 G at the output of two axes and about 1 G at the output of the third axis.

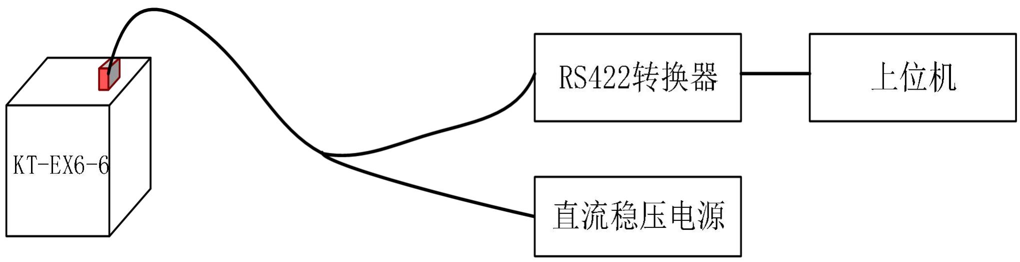


Figure 6-1 Connection diagram of IMU6-6 test

7 Use and maintenance requirements

Before using IMU6-6, the installation position of the system must be checked to ensure that it is installed correctly. Carefully check the connection of each signal line to ensure that the connection is correct.

Before power-on, check the cable network contact and power supply value, and the polarity of power supply shall not be reversed.

In use, the mechanical grounding of the system shall be well grounded.

This product contains precision instruments. Knocking and falling are prohibited.

This product should be stored in a well-ventilated warehouse with a temperature of (15 ~ 35) °C, a relative humidity of not more than 75%, and free of acid, alkali and corrosive gases.

8 Common fault phenomena

Several common faults that may occur during the use of IMU6-6 are listed below. You can check them according to the fault mode first. If there are other problems, you can contact the after-sales service.

Table 8-1 Failure Mode Conditions

Serial number	Fault symptom	Cause of failure
1.	Abnormal current output (large or small)	Abnormal power supply of the product caused by excessive power supply voltage (beyond the tolerance of the product) or reverse connection of the positive

		and ground of the power supply
2.	Current output is 0	The power cable inside the product is disconnected.
3.	There is no data on the serial port	1) If the serial port transceiver cable is connected incorrectly, the product Tx shall be connected to the user Rx, and the product Rx shall be connected to the user Tx; 2) The serial port cable inside the product is disconnected
4.	Incorrect serial port data	Receiving serial port setting error, such as baud rate, parity bit, etc.
5.	Unpacking data exception	Unpacking function writing error, such as high and low byte order error, etc
6.	Glitch or jitter in sensor data	The product was not tested in a static environment while collecting data
7.	Sensor does not respond to external input	No Response Due to Soldering Problem of Sensor Sensing Element

Appendix A Packing List

Product packing list

Serial number	Name	Quantity	Unit	Remark
1	Products	1	Taiwan	
2	Product certificate	1	Share	
3	Product certificate	1	Share	
4	Instructions for use (electronic version)	1	Share	
5	Anti-static packaging bag	1	A	

Appendix B CRC Lookup Table and Lookup Function

Lookup table for B1 CRC32

static Uint32 crc_table[256]={
0x00000000, 0x04c11db7, 0x09823b6e, 0x0d4326d9, 0x130476dc, 0x17c56b6b, 0x1a864db2,
0x1e475005, 0x2608edb8, 0x22c9f00f, 0x2f8ad6d6, 0x2b4bcb61, 0x350c9b64, 0x31cd86d3,
0x3c8ea00a, 0x384fbdbd,0x4c11db70, 0x48d0c6c7, 0x4593e01e, 0x4152fda9, 0x5f15adac,
0x5bd4b01b, 0x569796c2, 0x52568b75, 0x6a1936c8, 0x6ed82b7f, 0x639b0da6, 0x675a1011,
0x791d4014, 0x7ddc5da3, 0x709f7b7a, 0x745e66cd,0x9823b6e0, 0x9ce2ab57, 0x91a18d8e,
0x95609039, 0x8b27c03c, 0x8fe6dd8b, 0x82a5fb52, 0x8664e6e5, 0xbe2b5b58, 0xbaea46ef,
0xb7a96036, 0xb3687d81, 0xad2f2d84, 0xa9ee3033, 0xa4ad16ea, 0xa06c0b5d, 0xd4326d90,
0xd0f37027, 0xddb056fe, 0xd9714b49, 0xc7361b4c, 0xc3f706fb, 0xceb42022, 0xca753d95,
0xf23a8028, 0xf6fb9d9f, 0xfbb8bb46, 0xff79a6f1, 0xe13ef6f4, 0xe5ffeb43, 0xe8bccd9a,
0xec7dd02d,0x34867077, 0x30476dc0, 0x3d044b19, 0x39c556ae, 0x278206ab, 0x23431b1c,
0x2e003dc5, 0x2ac12072, 0x128e9dcf, 0x164f8078, 0x1b0ca6a1, 0x1fcdbb16, 0x018aeb13,
0x054bf6a4, 0x0808d07d, 0x0cc9cdca, 0x7897ab07, 0x7c56b6b0, 0x71159069, 0x75d48dde,
0x6b93dddb, 0x6f52c06c, 0x6211e6b5, 0x66d0fb02, 0x5e9f46bf, 0x5a5e5b08, 0x571d7dd1,
0x53dc6066, 0x4d9b3063, 0x495a2dd4, 0x44190b0d, 0x40d816ba,0xaca5c697, 0xa864db20,
0xa527fdf9, 0xa1e6e04e, 0xbfa1b04b, 0xbb60adfc, 0xb6238b25, 0xb2e29692, 0x8aad2b2f,
0x8e6c3698, 0x832f1041, 0x87ee0df6, 0x99a95df3, 0x9d684044, 0x902b669d, 0x94ea7b2a,
0xe0b41de7, 0xe4750050, 0xe9362689, 0xedf73b3e, 0xf3b06b3b, 0xf771768c, 0xfa325055,
0xfef34de2, 0xc6bcf05f, 0xc27dede8, 0xcf3ecb31, 0xcbffd686, 0xd5b88683, 0xd1799b34,
0xdc3abded, 0xd8fba05a,0x690ce0ee, 0x6dcdfd59, 0x608edb80, 0x644fc637, 0x7a089632,
0x7ec98b85, 0x738aad5c, 0x774bb0eb, 0x4f040d56, 0x4bc510e1, 0x46863638, 0x42472b8f,
0x5c007b8a, 0x58c1663d, 0x558240e4, 0x51435d53,0x251d3b9e, 0x21dc2629, 0x2c9f00f0,
0x285e1d47, 0x36194d42, 0x32d850f5, 0x3f9b762c, 0x3b5a6b9b, 0x0315d626, 0x07d4cb91,
0x0a97ed48, 0x0e56f0ff, 0x1011a0fa, 0x14d0bd4d, 0x19939b94, 0x1d528623,0xf12f560e,
0xf5ee4bb9, 0xf8ad6d60, 0xfc6c70d7, 0xe22b20d2, 0xe6ea3d65, 0xeba91bbc, 0xef68060b,
0xd727bbb6, 0xd3e6a601, 0xdea580d8, 0xda649d6f, 0xc423cd6a, 0xc0e2d0dd, 0xcda1f604,
0xc960ebb3,0xbd3e8d7e, 0xb9ff90c9, 0xb4bcb610, 0xb07daba7, 0xae3afba2, 0xaafbe615,

0xa7b8c0cc, 0xa379dd7b, 0x9b3660c6, 0x9ff77d71, 0x92b45ba8, 0x9675461f, 0x8832161a, 0x8cf30bad, 0x81b02d74, 0x857130c3, 0x5d8a9099, 0x594b8d2e, 0x5408abf7, 0x50c9b640, 0x4e8ee645, 0x4a4ffbf2, 0x470cdd2b, 0x43cdc09c, 0x7b827d21, 0x7f436096, 0x7200464f, 0x76c15bf8, 0x68860bfd, 0x6c47164a, 0x61043093, 0x65c52d24,0x119b4be9, 0x155a565e, 0x18197087, 0x1cd86d30, 0x029f3d35, 0x065e2082, 0x0b1d065b, 0x0fdc1bec, 0x3793a651, 0x3352bbe6, 0x3e119d3f, 0x3ad08088, 0x2497d08d, 0x2056cd3a, 0x2d15ebe3, 0x29d4f654,0xc5a92679, 0xc1683bce, 0xcc2b1d17, 0xc8ea00a0, 0xd6ad50a5, 0xd26c4d12, 0xdf2f6bcb, 0xdbee767c, 0xe3a1cbc1, 0xe760d676, 0xea23f0af, 0xeee2ed18, 0xf0a5bd1d, 0xf464a0aa, 0xf9278673, 0xfde69bc4,0x89b8fd09, 0x8d79e0be, 0x803ac667, 0x84fbdbd0, 0x9abc8bd5, 0x9e7d9662, 0x933eb0bb, 0x97ffad0c, 0xafb010b1, 0xab710d06, 0xa6322bdf, 0xa2f33668, 0xbcb4666d, 0xb8757bda, 0xb5365d03, 0xb1f740b4

};

B2 Table lookup function

```
void CRC32(Uint16 *pch,int len)
{
Uint32 reg = 0xFFFFFFFF; //initial value
    int i;
int Res=0; Remainder of//4
if((len%4)! =0)
    {
Res=4-len%4; //Need to supplement the number of 0 for calculating crc32
    }
   for( i = 0; i < len; i++)
    {
        reg = (reg<<8) ^ crc_table[(((reg>>24)&0xFF) ^ pch[i])];
    }
for( i = 0; i < Res; I + +)//Extra 0 needs to be asked to participate in CRC
    {
        reg = (reg<<8) ^ crc_table[(((reg>>24)&0xFF) ^ 0x00)];
    }
    crc_data[0] = (reg>>24) & 0xFF;
    crc_data[1] = (reg>>16) & 0xFF;
```

```
    crc_data[2] = (reg>>8) & 0xFF;

    crc_data[3] = reg & 0xFF;

    return;

}
```

The CRC _ data [0] to the CRC _ data [3] is the calculated CRC32 value.

Appendix C

Physical drawing of product