Technical Manual Rev1.1

CruizCore® R1370P

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1. Introduction

The CruizCore® R1370P (see Figure 1) is a digital gyroscope and accelerometer used for measuring angular rates, heading angle (also known as orientation or yaw) and accelerations under dynamic conditions. It is a highly compact, light, and fully self-contained device. Internally the R1370P contains a MEMS gyroscope, 3 axis accelerometer, internal voltage regulator, signal processing circuitry, AD converter and a RISC microprocessor running our patented error correcting algorithm. The CruizCore® R1370P uses an adaptive reduced order Kalman filter to reduce the errors that affect this type of sensors (i.e. bias drift, scale factor, asymmetry), as the result it produces very accurate stabilized angular rates and heading angle. The start-up time is less than 1 second, which is used to compute bias parameters; it does not require further calibration thereafter. The R1370P is the best single axis rate measuring solution for navigation applications.

The CruizCore® R1370P has the following features:

- UART output (I2C optional)
- Low power consumption
- Compact package
- Customized bandwidth (optional)
- Fast startup
- Fully self-contained
- Rate output
- Angle output
- 3 Axis-acceleration output

The CruizCore® R1370P is highly optimized for the following applications:

- Robotics navigation
- Platform stabilization
- Attitude reference systems
- Control and guidance systems
- Unmanned air vehicles (UAV) and, Micro air vehicles
- Automotive testing
- Vehicle instrumentation
- Cleaning robots

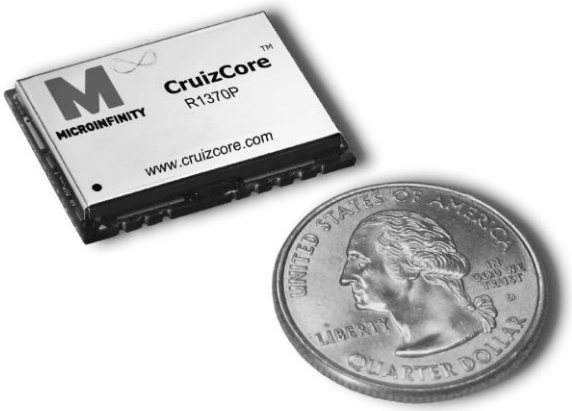

Figure 1: CruizCore® R1370P

NOTICE: We recommend extensive testing of this product before using it in a final application. Specifically, this product should be tested in the same environmental conditions that it is intended to be used. Furthermore, we strongly recommend caution when using our product in sensitive applications that can cause injures, death or property damage due to the wrong operation of this product, which may be caused by unexpected environmental changes such as temperature, shock, excessive and continuous vibration, etc. These applications include but are not limited to:

- **Aircraft equipment**
- **Air vehicles**
- **Aerospace equipment**
- **Underwater vehicles**
- **Medical equipment**
- **Transportation equipment**
- **Disaster prevention/crime prevention equipment**
- **Applications which require especially high reliability and accuracy**

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2. Hardware Description

2.1. System Description

The CruizCore® R1370P is a compact, light and low-power consumption digital gyroscope and accelerometer. It uses a MEMS rate and acceleration sensors. It has an internal voltage regulation to minimize the effects of power supply noise. The input voltage is in the range of 3.2 V to 5.5 V. We strongly recommend **3.3 V** for low power consumption applications and to prevent problems associated with sensor heating.

2.2. System Operation

The simple operational diagram of the CruizCore® R1370P is shown in Figure 2. The analog signal from a MEMS sensor is converted into digital format using a fast and precise A/D converter. The Signal Processing and the Kalman filter steps are used to compensate for the sensor errors. A patented Error Correction algorithm is also used to compensate sensor errors, which are fed back to the Kalman filter.

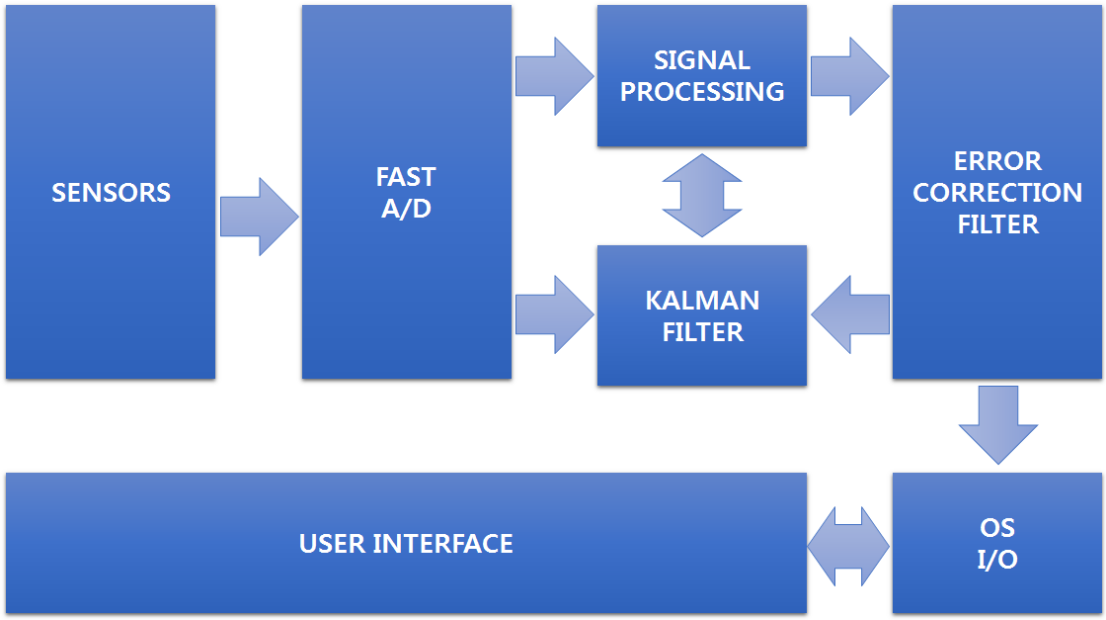

Figure 2: CruizCore® R1370P system block diagram.

2.3. Pin Description

The CruizCore® R1370P is provided in an 18-pin surface mount package configuration (see Figure 3). The pin description is presented in Table 1.

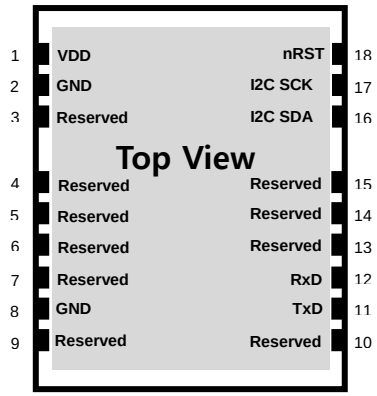

Figure 3: CruizCore® R1370P pin arrangement.

Table 1: CruizCore® R1370P pin description.

Pin Name	Function
VDD	Main power (3.2~5.5VDC)
GND	Power ground
TxD	UART transmit data
RxD	UART receive data
nRST	System reset input
I2C SCK	I2C clock line
I2C SDA	I2C data line
Reserved	Reserved for additional functions

Observe the following recommendations:

- The communication and I/O interface voltage levels are 3.0V.
- The UART default configuration is 115,200 bps, 8 data bit, 1 stop bit, and no parity. Other configurations are also available optionally.
- The nRST pin controls the system reset, for this purpose an open collector logic signal is required.
- Leave the unused pins disconnected (open).

2.4. Mounting Information (Coordinate System)

The CruizCore® R1370P coordinate system has its sensitive axis perpendicular to the device flatter area (see Figure 4), therefore the gyro will show a positive angular rate (and angle increment) when its sensitive axis is rotated in the clock-wise direction (other coordinate systems are available as an option). Incorrect mounting can produce misalignment errors that have similar effect as the scale factor errors, and therefore can be treated as such. If this error is significant we recommend re-calculating the scale factor using a single-axis rate table.

2.5. Sensor start-up

The CruizCore® R1370P startup time is less than one second, it internally compensates for errors due to changes in temperature. However, sudden temperature changes shortly after powering-on the unit can cause static rate errors. If such temperature chances are expected, we recommend leaving the gyro stationary for about 4 seconds after startup.

WARNING: The CruizCore® R1370P must remain stationary during the startup time, failing to do so will introduce a constant drift in the output.

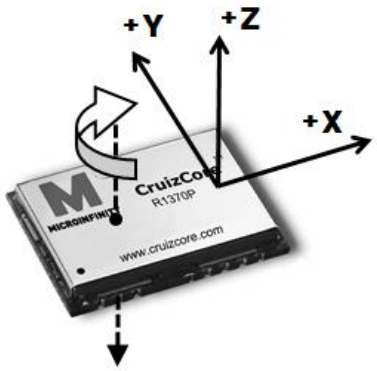

Figure 4: CruizCore® R1370P coordinates system

3. Software Description

3.1. Output Data Format

The CruizCore® R1370P provides rate, angle and acceleration outputs. The angle output is relative and can be affected by several conditions such as sampling rate variations, bandwidth limitation, dynamic range, alignment, and device mounting.

3.1.1. SYSTEM INFORMATION

When the CruizCore® R1370P is powered up, it transmits the system information. For example:

%CruizCore R13P rX. X

%SW Ver X.XX-XX

%(c) 2002-2015 Microinfinity Co., Ltd.

3.1.2. INTEGER OUTPUT FORMAT

Following the system information the CruizCore® R1370P starts transmitting the sensor data packages. The CruizCore® R1370P provides rate, angle and acceleration outputs. The output format is shown in Figure 5: Cruizcore® R1370P data packet format and is described in Table 2. The integer output consists on a 2 byte header, a 1byte index, a 1byte reserved, a 10 byte data section and 1 byte checksum. The output in this format is given in hundredths of degrees, i.e. a 1 degree angle will be displayed as 100 (or 0x64 HEX). The output voltage level of the serial port is 3.0 V. An example of the data packet sample is provided in Table 3.

HEADER		DATA												Check sum
		Index	ANGLE		RATE		X-axis Acceleration		Y-Axis Acceleration		Z-Axis Acceleration		Reserved	
0xAA	0x00													
2byte		1byte	2byte		2byte		2byte		2byte		2byte		1byte	1byte

Figure 5: CruizCore® R1370P data packet format

Table 2: CruizCore® R1370P data fields description.

OUTPUT DATA	BYTE	COMMENTS
HEADER	1-2	Hex value is: 0xAA00
INDEX	3	0x00 ~ 0xFF
ANGLE*	4-5	Provided in hundredths of deg. and normalized to ±180 deg.
RATE*	6-7	Provided in hundredths of deg/sec
X-axis Acceleration	8-9	Provided in 1mg resolution
Y-axis Acceleration	10-11	Provided in 1mg resolution
Z-axis Acceleration	12-13	Provided in 1mg resolution
RESERVED	14	
CHECKSUM*	15	Is equal to: index + angle(LSB) + angle(MSB) + rate(LSB) + rate(MSB) + Xacc(LSB) + Xacc(MSB) + Yacc(LSB) + Yacc(MSB) + Zacc(LSB) + Zacc(MSB) + reserved

* First byte is the least significant

Table 3: Data packet parsing example.

Parameter	Comments/Calculations
Data packet	*0xAA00E47000C8003400210002010074*
Index	Index(hex) = 0xE4 = 228
Checksum	CHEKSUM (hex) = 0xE4+0x70+0x00+0xC8+0x00+0x34+0x00+0x21+ 0x00+0x02+0x01+0x00 = 0x74
Rate output	Rate (hundredths deg/sec) = 0x7000 (hex) = 112 Rate (deg/sec) = 112/100 = 1.12
Angle output	Angle (hundredths deg) = 0xC800 (hex) = 200 Angle (deg) = 200/100 = 2.00
Acceleration output	Acceleration (1mg resolution) = 0x0201 (hex) = 258 Acceleration (G) = 258mg

3.2. Input Command Format

The CruizCore® R1370P can accept input commands, that are used to change the baud rate, data output rate. The input command sets all the parameters at once, if the user does not want to change a certain parameter; the field can be skipped by leaving the respective field empty, still the comma character must be included. The CruizCore® R1370P only recognizes the input commands summarized in Table 4, no blank or other characters can be used.

Table 4: Command Summary.

Field	Command	Separator	Example
INIT	$MIA	COMMA (,)	$MIA,
FORMAT	I	COMMA (,)	I,
BAUD RATE	B,BAUDRATE	COMMA (,)	B,115200,
OUTPUT RATE	R	COMMA (,)	R,100,
TYPE	D	COMMA (,)	D,
OUTPUT	Y	COMMA (,)	Y,
FLASH	Y	COMMA (,)	Y,
CHECKSUM	SUM of COMMAND	ASTERISK(*)	*C4
SOFTWARE RESET	$MIB,RESET*87		

3.2.1. INIT Field

Command start identifier. Must be '$MIA'.

3.2.2. FORMAT Field

The 'I' means integer data format. The floating point and ASCII formats are not available on R1370P.

3.2.3. BAUD RATE Field

The baud rate setting can be chosen from the following available options: 115200, 57600, 38400, 28800, 19200, 9600, and 4800. Notice that the baud rate is set before the data output rate, therefore a low baud rate can limit the maximum data output rate. For example, for 4800 baud rate the maximum data output rate is only 25Hz. Table 5 shows the maximum output rates for a given baud rate.

Table 5: Baud rate and maximum output rate.

BAUD RATE	115200	57600	38400	28800	19200	9600	4800
MAX OUTPUT RATE	100Hz	100Hz	100Hz	100Hz	100Hz	50Hz	25Hz

3.2.4. OUTPUT RATE Field

Data output rate setting. This command determines data output rate, the following are the valid rates: 100Hz, 50Hz, 25Hz, and 10Hz.

3.2.5. TYPE Field

Data type setting. The rate and angle are provided in 'Degree' (D) format. The 'Radian' (R) format is not available on R1370P.

3.2.6. OUTPUT Field

Output setting 'Y' means all the data will be provided, and 'N' means none of the data will be provided. However, the 'N' command is not available on R1370P. That means the data will be provided all the time.

3.2.7. FLASH Field

This command determines whether the setting is stored or not in flash memory. But in case of R1370P, the 'Y' command is only available. So the settings are always stored in the flash memory and they will remain even after powering down the unit.

3.2.8. CHECKSUM Field

This is the sum of character after '$' and before '*', and it is represented in HEX value.

3.2.9. Software Reset

This command '$MIB,RESET*87' resets the device. The reset command has its own identifier, which is different that the other available commands. Refer to 2.5. for other details about sensor initialization.

3.2.10. Default settings

Table 6 shows the factory default settings for the CruizCore® R1370P, and Table 7 presents some examples of valid commands.

Table 6: Default settings.

FIELD	DEFAULT SETTING
FORMAT	I : integer format
BAUD RATE	B,115200 : 115200bps
OUTPUT RATE	R,100 : 100Hz
TYPE	D : Degree
OUTPUT	Y : all the data valid

3.2.11. Example

Table 7: Command examples.

Ex 1.	**SETTING**	Integer, 115200bps, 100Hz, Degree, Output enabled, Flash saved
	COMMAND	$MIA,I,B,115200,R,100,D,Y,Y*C4
Ex 2.	**SETTING**	Integer, 19200bps, 100Hz, Degree, Output enabled, Flash saved
	COMMAND	$MIA,I,B,19200,R,100,D,Y,Y*97
Ex 3.	**SETTING**	50Hz (The other settings are maintained.)
	COMMAND	$MIA,,,,R,50,,,*EE
Ex 4.	**SETTING**	100Hz (The other settings are maintained.)
	COMMAND	$MIA,,,,R,100,,,*1A

3.3. Data Parsing C Code

The following C program shows how to parse a CruizCore® R1370P output data packet.

```
//This program assumes that the complete data package has been conveniently stored in the
// data_string array variable that is passed as an argument. After parsing the data packet,
// this function stores the results in the global variables gRate, gAngle, gX_acc, gY_acc, gZ_acc.
// If successful the function returns true otherwise false

extern float32_t   gAngle;
extern float32_t   gRate;
extern float32_t   gX_acc;
extern float32_t   gY_acc;
extern float32_t   gZ_acc;

bool parse_data(uint8_t *data_string)
{
      uint8_t   index;
      int16_t   angle;
      int16_t   rate;
      int16_t   x_acc;
      int16_t   y_acc;
      int16_t   z_acc;
      uint8_t   check_sum;

            //Verify packet heading information
            if(data_string[0] != 0xAA || data_string[1] != 0x00)
            {
                  printf("Data heading error");
                  return false;
            }
      //Assemble data
      index = data_string[2];
      rate = (data_string[3] & 0xFF) | ((data_string[4] << 8) & 0xFF00);
      angle = (data_string[5] & 0xFF) | ((data_string[6] << 8) & 0XFF00);
      x_acc = (data_string[7] & 0xFF) | ((data_string[8] << 8) & 0xFF00);
      y_acc = (data_string[9] & 0xFF) | ((data_string[10] << 8) & 0XFF00);
      z_acc = (data_string[11] & 0xFF) | ((data_string[12] << 8) & 0xFF00);
      reserved = data_string[13];
      //Verify checksum
      check_sum = data_string[2] + data_string[3] + data_string[4] + data_string[5]
                        + data_string[6] + data_string[7] + data_string[8] + data_string[9]
                        + data_string[10] + data_string[11] + data_string[12] + data_string[13];
            if((check_sum != data_string[14])
            {
                  printf("Checksum mismatch error");
                  return false;
            }
      //Scale and store data
      gRate = rate / 100.0;
      gAngle = angle / 100.0;
      gX_acc = x_acc;
      gY_acc = y_acc;
      gZ_acc = z_acc;
      return true;
}
```

4. Application

4.1. Package Information

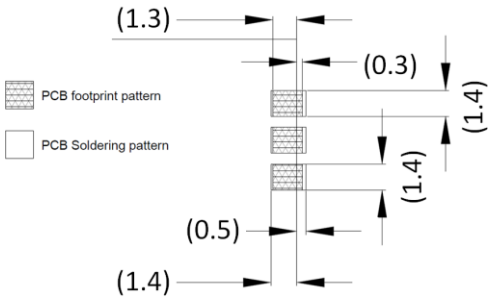

Figure 7: CruizCore® R1370P soldering pad

All the dimensions are shown in millimeters.

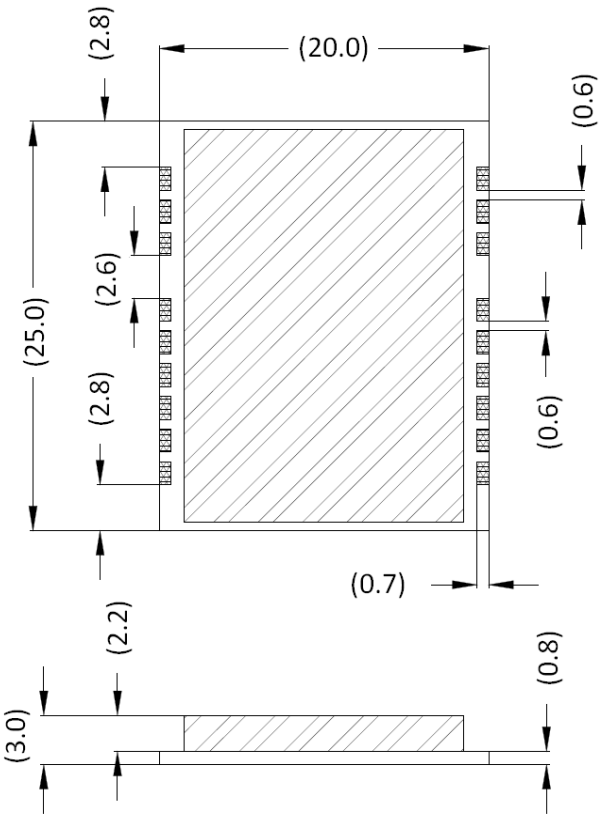

Figure 6: CruizCore® R1370P top view.

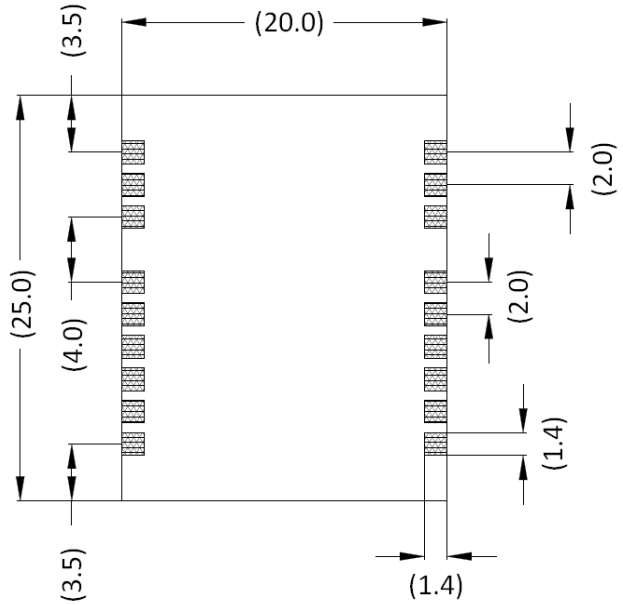

Figure 8: CruizCore® R1370P bottom view

4.2. Application Example

Figure 9 presents a typical RS232 voltage level shifter circuit that can be used to communicate the CruizCore® R1370P with a personal computer. The nRST pin can be connected with master reset and must be open collector logic.

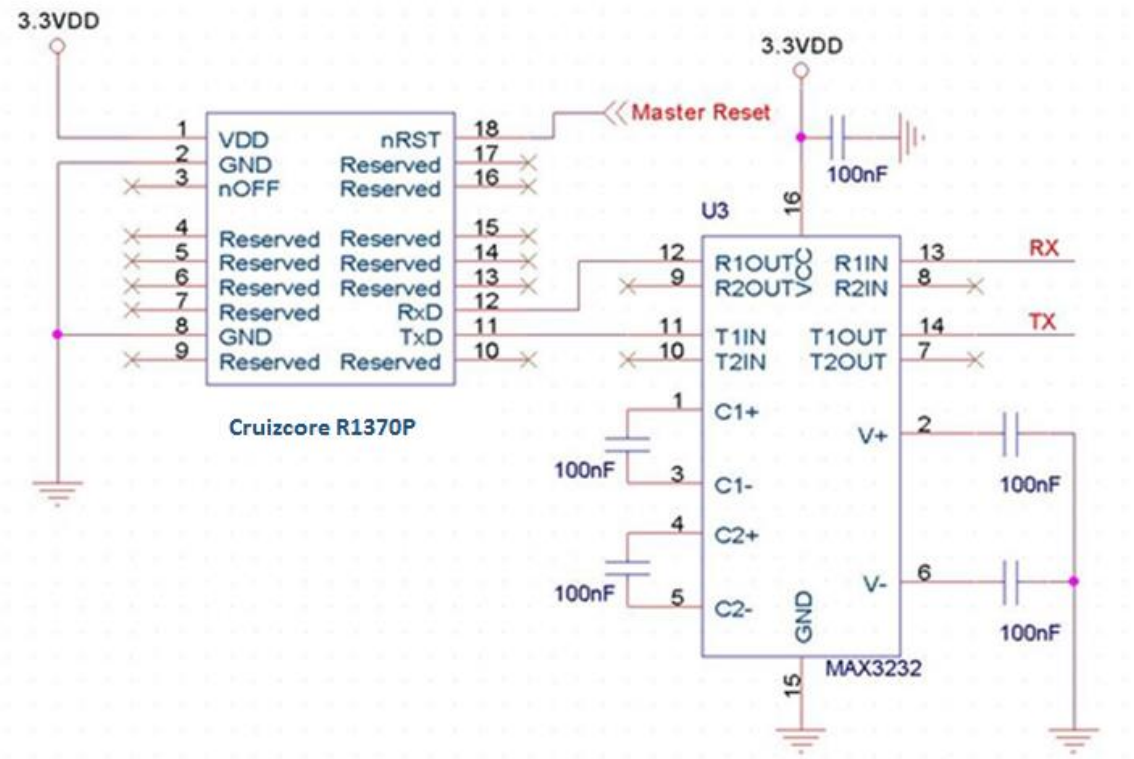

Figure 9: CruizCore® R1370P with RS232 level converter

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