

JW24F14

3D acceleration sensor



Code Mercenaries

1. Features

- USB interface (low speed)
- Full USB V1.1/2.0 compliance
- Full USB HID 1.1 compliance
- 3 axis acceleration measurement
- 14 bit resolution for each axis
- $\pm 1g$, $\pm 1.5g$, $\pm 2g$, $\pm 3g$, $\pm 4g$, $\pm 8g$, or $\pm 16g$ software selectable range
- Data can be read via joystick input or direct
- 8 buttons/aux inputs
- Uses a state of the art compact MEMS sensor
- Sensor settings can be stored in EEPROM
- Single +5V power supply
- Available as module, kit, and water proof unit

1.1 Variants

JoyWarrior24F14 are available as either a completely assembled module, a kit containing the module, cable and enclosure, or as a water proof unit in a rugged plastic enclosure.

2. Functional overview

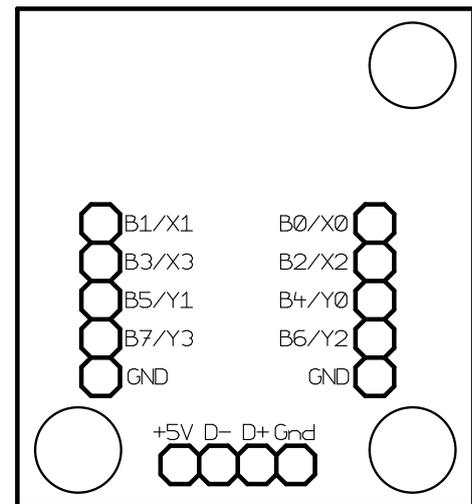
JoyWarrior24F14 uses a MEMS solid state 3 axis acceleration sensor for acceleration or inclination measurement.

By default the data is reported as joystick data which allows to use JoyWarrior24F14 with existing applications and simplifies implementation for applications where no detailed handling of the sensor parameters is required.

Full access to the sensor data and settings is possible via a generic HID interface (similar to IO-Warrior).

Range, bandwidth, trigger levels, and other parameters can be set permanently in the sensors internal EEPROM. This allows to program the sensor for a specific application and then use the joystick data for easy access.

3.0 Pin description JoyWarrior24F14-MOD



D+, D-, Vcc, GND

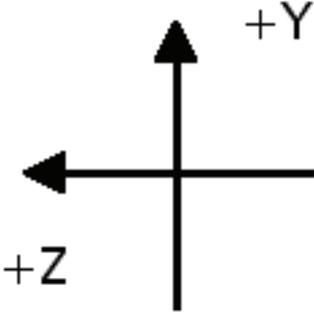
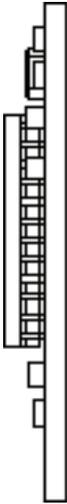
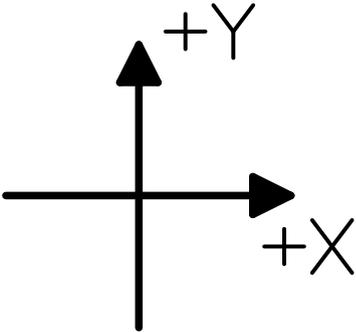
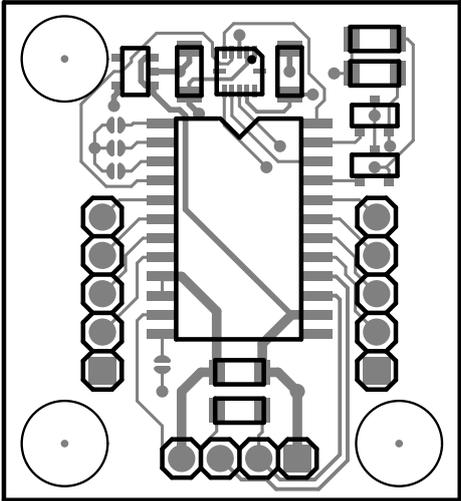
Connect to a USB cable with a type A plug on its other end.

B0..B7

Inputs for the buttons or auxiliary inputs. Connect contacts closing to ground or pull low. Internal pull up resistors.

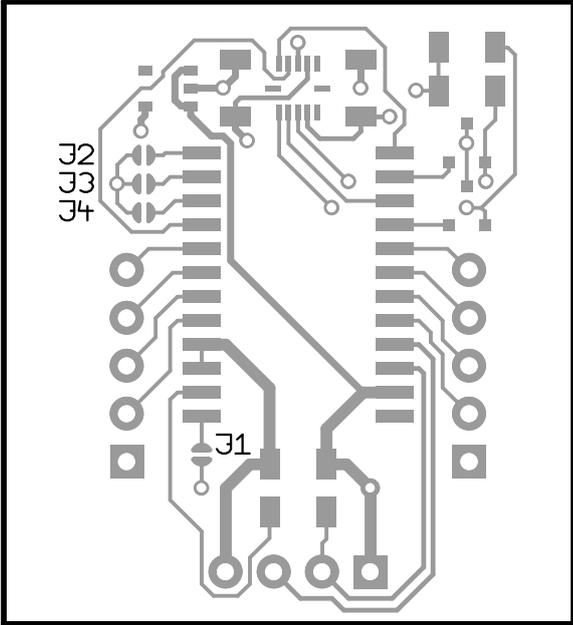
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3.2 Axis orientation for JoyWarrior24F14-MOD

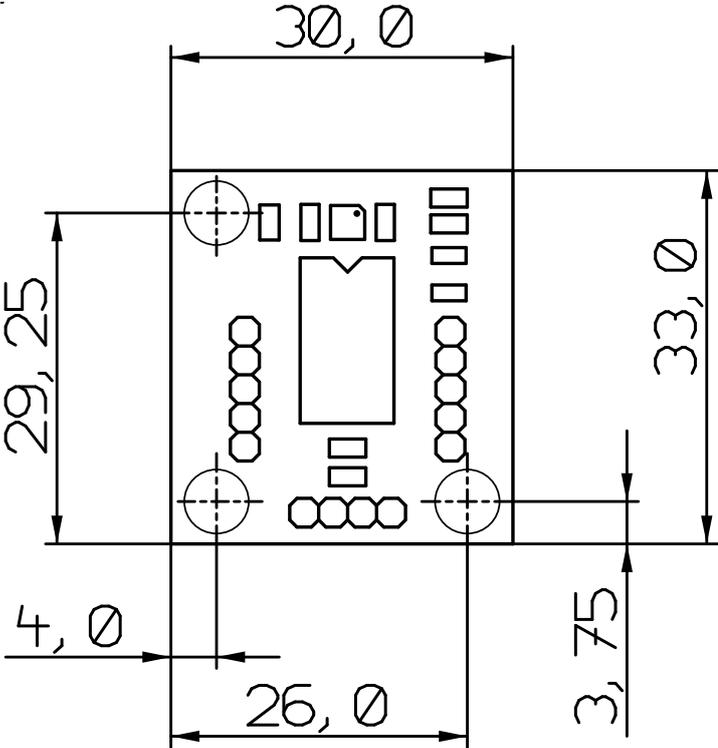


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3.3 Jumper positions for JoyWarrior24F14-MOD



3.4 Mechanical dimensions



All dimensions in mm
Mounting holes 2.5mm

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3.5 Jumper descriptions:

J1 - RAW, closing this jumper does activate the RAW mode where unmapped data is reported.

J2, J3, J4 - unused, don't close these jumpers.

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4. Device operation

By following the USB HID specifications JoyWarrior chips are able to work with most operating systems without the need to supply special drivers. Any operating system with support for USB HID devices and game controllers will have the necessary drivers already in place.

The three axes of the sensor are reported as joystick axes X, Y, Z with 14 bit resolution.

4.1 Axis orientation

In standard operation the sensor data is mapped to match the standard behaviour of joystick axes. The signed 14 bit data from the sensor is changed to unsigned format with 8191 being the neutral position (i.e. 0g). The orientation of the sensor Y axis is inverted. This results in a typical axis orientation for joysticks when the module is in a position with the components on top and the sensor facing away from the user.

By pulling the RAW input high the mapping is switched off so the sensor data is reported unprocessed. While this is less useful for joystick operation it may simplify using the data for measurement applications.

4.1.1 Data filtering

JoyWarrior24F14 uses an internal median filter to decimate the raw data stream of the sensor (about 2000 values/s) to the USB report rate (125 reports/s). This also reduces the noise content of the signal.

4.2 Operation with Windows

Any Windows versions 98 and newer and 2000 and newer will work with JoyWarrior. Older versions of Windows do not support USB. The support software is tested with Windows 2000 and newer.

Upon connecting a JoyWarrior based device for the first time you may be asked to perform the standard driver install.

After the driver installation has completed you should be able to see the device in the "Game Controllers" control panel and be able to access it via DirectInput. Also a generic HID device should show up in the device manager.

Do not use the calibration function of Windows, if the calibration function is used the data reported by JoyWarrior24F14 gets modified by Windows. To get rid of a calibration you have to remove the JoyWarrior24F14 in the device manager, then unplug, replug, and reinstall it.

Preferably you should read data in the uncalibrated format. See the programming examples for details.

4.3 Operation with MacOS

On MacOS X access is available via the HIDManager. Older MacOS versions are not tested.

There will be no warnings or dialogs when a properly functioning JoyWarrior based device is connected under MacOS X, it will simply start to work.

4.4 Low level sensor access

Reading the sensor data via the joystick interface is convenient for most applications. However in some situations a more detailed control over the sensor may be required, setting the parameters of the sensor is also not possible via the joystick interface.

To directly access all registers of the MEMS sensor JoyWarrior24F14 does have a second interface (an interface is a logical device in a USB device) that identifies as a generic HID class device. Interface 0 is the joystick function that will be controlled by a system driver. Interface 1 identifies as a generic HID function and can be controlled from application level on most operating systems.

For details of the sensor data please refer to the Bosch BMA180 data sheet.

When accessing the sensor directly make sure you have understood the working details of the sensor. There are a couple registers which must not be overwritten, otherwise the calibration of the sensor may be lost permanently.

Data is sent to the sensor in a report with the following format:

0	1	2	3	4	5	6	7
Flag/Cnt	Dat0	Dat1	Dat2	Dat3	Dat4	Dat5	Dat6

Flag/Cnt - Contains a flag to disable the joystick data polling and a data count:

7 - Disable flag, 1 = disable

6 - unused, zero

5 - unused, zero

4 - unused, zero

3 - unused, zero

2 - data count MSB

1 - data count

0 - data count LSB

Data count may be 0 to 7, denoting the number of bytes to write to the sensor or read from it.

It is recommended to disable the joystick data polling while communicating with the sensor. So the first report before actually starting communication with the sensor should have a \$80 in the first byte and no data.

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Since the communication with the sensor works via SPI the same number of bytes as written to the sensor is read from it at the same time. The data read from the sensor is returned in a report with the following format:

0	1	2	3	4	5	6	7
Count	Dat0	Dat1	Dat2	Dat3	Dat4	Dat5	Dat6

Count is the number of bytes read from the sensor, it may range from 0 to 7. Since the first byte written to the sensor is always the register address the first byte read contains random data.

If a pure write transaction to the sensor is done the read data report is also returned, it will contain random data but a correct count.

4.5 Calibration

The sensors are factory calibrated for neutral position and range. Due to mechanical tolerances during soldering the MEMS sensor element on the module and mounting the module in the application a recalibration of the neutral position may be necessary.

A calibration tool is provided that allows to calibrate the neutral position. To do the calibration the sensor needs to be in a stable horizontal position, with the components facing upwards. Start the calibration tool and click on "calibrate", don't move the sensor while the calibration proceeds.

JoyWarrior24F14 allows calibration to within $\pm 5\text{mg}$ of zero.

In addition to the neutral position calibration the gain can also be calibrated, though the calibration tool does not support setting the gain values. It is not recommended to change the gain values unless the process for this type of calibration is properly understood. Once overwritten there is no way to retrieve the original gain settings from the sensor. Writing the gain values can permanently decalibrate your sensor.

4.6 Sensor parameters

The sensor programming tool allows to set the relevant sensor parameters which can be used with the JoyWarrior24F14.

Primary parameters are the measurement range and the filter setting.

When using the sensor programming tool you have the option to write to the working registers or the EEPROM of the sensor. Settings written to the EEPROM will be stored permanently and will be

used by the sensor after a power down or reset.

Writing to the working registers should be used to test settings prior to overwriting the factory settings in the EEPROM. Factory settings can not be restored from within the sensor.

It is also possible to store the settings to a file. The settings file may then either be used by the programming tool or by the automated programming tool, which is intended to set multiple sensors to identical parameters.

To use the automatic programming tool you first have to create a settings file with the programming tool. Then start the automatic programming tool and load the settings file. Any JoyWarrior24F14 that gets connected now will automatically get the settings written to its sensor EEPROM.

4.7 Measurement range

On JoyWarrior24F14 the resolution is always 14 bits and the measurement range can be $\pm 1\text{g}$, $\pm 1.5\text{g}$, $\pm 2\text{g}$, $\pm 3\text{g}$, $\pm 4\text{g}$, $\pm 8\text{g}$, or $\pm 16\text{g}$.

When written to the sensor EEPROM the selected range will automatically be used every time the sensor is powered up.

4.8 Bandwidth

The sensor element of JoyWarrior24F14 has an internal filter to reduce the signal bandwidth. The filter can be set to work as a low pass with cut off at 10, 20, 40, 75, 150, 300, 600, or 1200Hz. Additionally a high pass filter with 1Hz cut off and a band pass for 0.2Hz to 300Hz are available.

Since the data rate is limited to 125 reports per second it does not make sense to use low pass filter settings above 75Hz.

Use of the lowest possible bandwidth for the chosen application is recommended to reduce the noise level.

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5. DC Characteristics

	Parameter	Min	Max	Units	Remarks
V _{cc}	Operating voltage	4.35	5.25	V	
I _{cc}	Operating supply current		20	mA	
I _{sb}	Suspend mode current (chip)		25	μA	Oscillator off
I _{sb}	Suspend mode current (module)		350	μA	Sensor working
R _{up}	Pull-up resistance	8	24	kΩ	
V _{ith}	Input threshold voltage	40%	60%	V _{cc}	
	USB Interface				
V _{oh}	Static output high	2.8	3.6	V	15kΩ±5% to GND
V _{ol}	Static output low		0.3	V	
V _{di}	Differential input sensitivity	0.2		V	$(D+) - (D-)$
V _{cm}	Differential input common mode range	0.8	2.5	V	
V _{se}	Single ended transceiver threshold	0.8	2.0	V	
C _{in}	Transceiver capacitance		20	pF	
I _{io}	Hi-Z State data line leakage	-10	10	μA	0V < V _{in} < 3.3V, Hi-Z State
R _{pu}	Bus pull-up resistance	1.274	1.326	kΩ	1.3kΩ±2% to V _{reg}
R _{pd}	Bus pull-down resistance	14.25	15.75	kΩ	15kΩ±5%

5.1 AC Characteristics

	Parameter	Min	Max	Units	Remarks
F _{iclk2}	Internal clock frequency	5.91	6.09	MHz	Clock synchronized to USB
	USB Driver Characteristics				
t _r	Transition rise time	75		ns	C _{Load} = 50pF
t _r	Transition rise time		300	ns	C _{Load} = 350pF
t _f	Transition fall time	75		ns	C _{Load} = 50pF
t _f	Transition fall time		300	ns	C _{Load} = 350pF
t _{rfm}	Rise/Fall time matching	80	125	%	
V _{crs}	Output signal crossover voltage	1.3	2.0	V	
	USB Data Timing				
t _{drate}	Low speed data rate	1.4775	1.5225	MBit/s	
t _{djr1}	Receiver data jitter tolerance	-75	75	ns	To next transition
t _{djr2}	Receiver data jitter tolerance	-45	45	ns	For paired transitions
t _{deop}	Differential to EOP transition skew	-40	100	ns	
t _{eopr1}	EOP width at receiver	165		ns	Rejects as EOP
t _{eopr2}	EOP width at receiver	675		ns	Accepts as EOP
t _{eopt}	Source EOP width	1.25	1.50	μs	
t _{udj1}	Differential driver jitter	-95	95	ns	To next transition
t _{udj2}	Differential driver jitter	-150	150	ns	To paired transition

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5.2 Absolute maximum ratings

Storage Temperature	-50°C to +150°C
Ambient Operating Temperature	0°C to +70°C
Supply Voltage on VCC relative to VSS	-0.5V to +7.0V
DC Input Voltage	-0.5V to VCC + 0.5V
Max. Output Current into any Pin	60mA
Power Dissipation	300mW
Static Discharge Voltage (USB and button inputs)	>2000V
Latch-up Current	>200mA
EEPROM write cycles (same byte)	≥1000
EEPROM data retention (at 55°C after 1000 cycles)	≥10 years
Mechanical Shock *	10,000g, ≤100μs 2,000g, ≤1ms ≤1.5m

Free fall onto hard surface *

*) Maximum shock specs apply for the sensor element only. Using the module in high g environments will require additional mechanical protection.

5.3 Sensor characteristics

	Parameter	Min	Typ	Max	Units
S _{1g}	Acceleration resolution at ±1g		8192 ±2%		LSB/g
S _{1.5g}	Acceleration resolution at ±1.5g		5460 ±2%		LSB/g
S _{2g}	Acceleration resolution at ±2g		4096 ±1.5%		LSB/g
S _{3g}	Acceleration resolution at ±3g		2730 ±2%		LSB/g
S _{4g}	Acceleration resolution at ±4g		2048 ±2%		LSB/g
S _{8g}	Acceleration resolution at ±8g		1024 ±2.5%		LSB/g
S _{16g}	Acceleration resolution at ±16g		512 ±3%		LSB/g
TCS	Temperature Coefficient of Sensitivity		±0.01		%/K
Off	Zero-g Offset at T _A = 25°C	-15		15	mg
Off	Zero-g Offset over lifetime, T _A = 25°C	-35		35	mg
	Zero-g Offset temperature drift		±0.25		mg/K
NL	Nonlinearity 1g, 1.5g, 2g	-0.10%		0.10%	%FS
NL	Nonlinearity 3g, 4g	-0.25%		0.25%	%FS
NL	Nonlinearity 8g, 16g	-0.75%		0.75%	%FS
n _{rms}	Output Noise (2g, 10Hz)		150		μg*√f (filter bandwidth)
/S	Cross Axis Sensitivity, relative between axes		0.1		%

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6. Ordering information

Partname	Order Code	Description	Package
JoyWarrior24F8 Module	discontinued		Module
JoyWarrior24F8	discontinued		SOIC24
JoyWarrior24F14 Module	JW24F14-MOD	3D acceleration sensor complete module	Module
QuakeCatcherKit2	QCKIT2	Kit containing module, cable, enclosure	Kit
JoyWarrior24F14-WP	JW24F14-WP	Water proof sensor with 1.8 m USB cable	water proof

The units listed here are standard products. Customized versions are available on request.

6.1 Packaging info

JW24F14-MOD modules come in antistatic boxes or antistatic bags packaged single or bulk. QCKIT2 and JW24F14-WP are individually packaged in blisters

6.2 USB VendorID and ProductID

By default all JoyWarrior controllers are shipped with the USB VendorID of Code Mercenaries (\$7C0 or decimal 1984) and a fixed ProductID. On request controllers can be equipped with the customers VendorID and ProductID. VendorIDs can be obtained from the USB Implementers Forum <www.usb.org>. Customized controllers are subject to minimum order quantities, contact <sales@codemercs.com> for details.

Following are the ProductIDs for the JoyWarrior controllers:

JoyWarrior24F8	\$1113
JoyWarrior24F14	\$1116

ProductIDs are independent of the package type.

See the JoyWarrior data sheet for version information.

6.3 Serial numbers

The JoyWarrior24F14 has a unique serial number in its device descriptor. These serial numbers can be used to simplify programming for multiple JoyWarriors connected to a single computer.

The serial numbers are factory programmed and can not be changed. Serial numbers are 8 digit hexadecimal numbers. No two chips of a type will be produced with identical serial numbers.

7. Revision history

Please refer to the JoyWarrior main data sheet for the revision history.

Shipping version of JW24F14 is V1.0.4.0

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