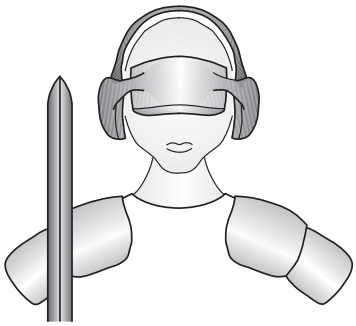
JW56FR1

6D acceleration + turn rate sensor



Code Mercenaries

1. Features

- USB interface (full speed)
- USB V1.1/2.0 compliance
- USB HID 1.1 compliance
- 3 axis acceleration measurement
- 3 axis angular rate measurement
- 16 bit resolution for each axis
- ±2 g, ±4 g, ±8 g, ±16 g software selectable acceleration measurement range
- 125, 245, 500, 1000, 2000 dps software selectable turn rate measurement range
- Data available via joystick API at 833 Hz
- High speed data at 6,664 kHz via generic HID
- 8 buttons/aux inputs
- Sensor settings can be stored in module
- Single +5 V power supply via USB
- Available as module, kit, and water proof unit

1.1 Variants

JoyWarrior56FR1 is available as either a pcb module, a kit (containing the module, cable and enclosure), or as a water proof unit in a rugged plastic enclosure.

2. Functional overview

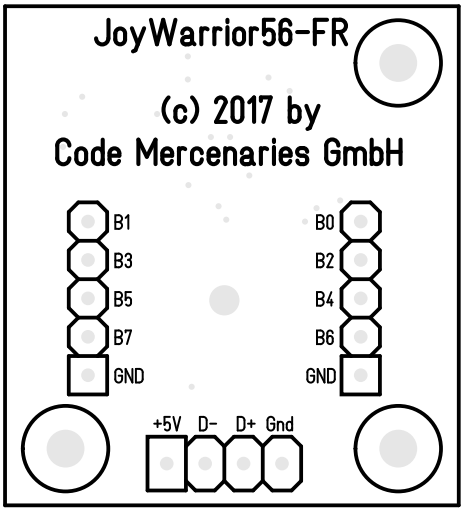
JoyWarrior56FR1 uses a MEMS solid state 6 axis sensor for acceleration and angular rate measurement. It may be used for motion, vibration, or orientation sensing.

By default the data is reported as joystick data which allows to use JoyWarrior56FR1 with existing applications and simplifies implementation by avoiding proprietary drivers.

High speed access to the sensor data is possible via a generic HID interface (similar to IO-Warrior).

Range and filter settings can be stored permanently in the sensor. This allows to program the sensor for a specific application and then use the joystick API for easy access.

3. Pin description JoyWarrior56FR1-MOD



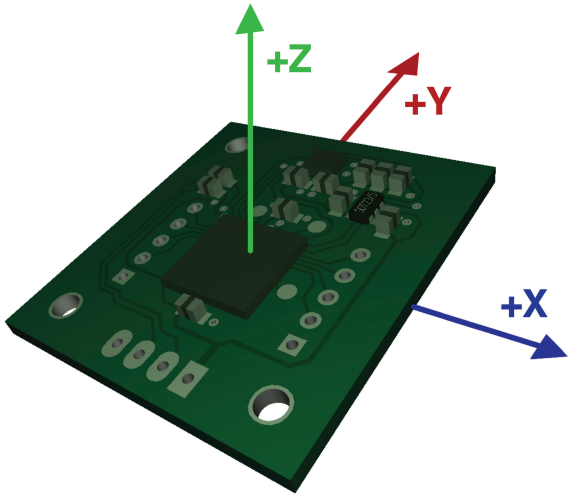
D+, D-, +5V, GND

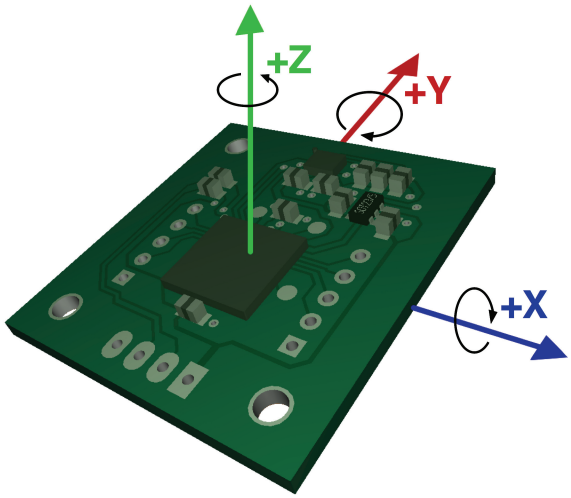
Connect to a USB cable.

B0..B7

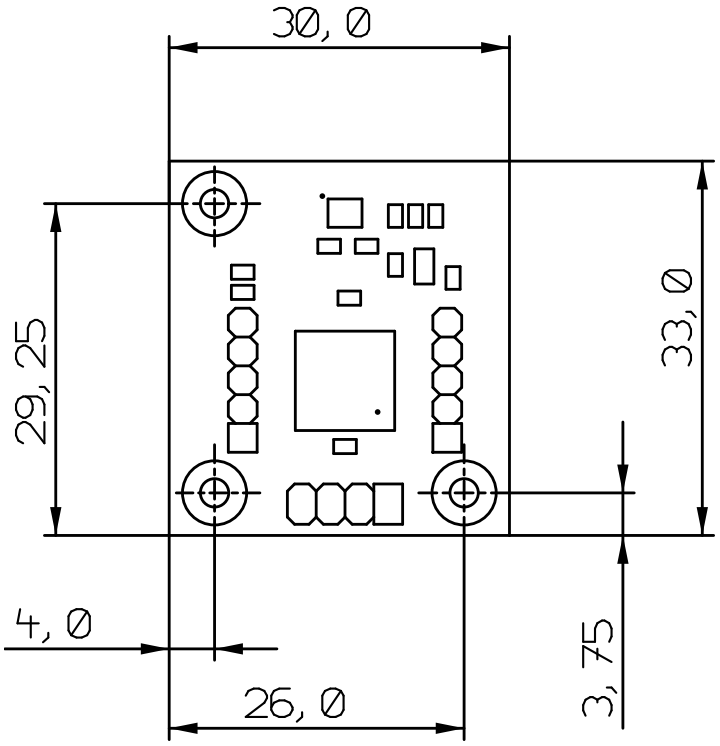
Inputs for the buttons or auxiliary inputs. Connect contacts closing to ground to pull low for active. Has internal pull up resistors.

3.1 Axis orientation for JoyWarrior56FR1-MOD





3.2 Mechanical dimensions



All dimensions in mm
Mounting holes 2.5 mm
Maximum thickness < 3 mm

4. Device operation

By following the USB HID specifications JoyWarrior56FR1 is 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 six axes of the sensor are reported as joystick axes X, Y, Z, rX, rY, rZ with 16 bit resolution each.

4.1 Backward compatibility

The JW56FR1-MOD is mechanically almost identical to the JW24F8-MOD and JW24F14-MOD. Only the pads for the USB connection have been enlarged to simplify soldering cables to the module.
All signal connections and the center line of the sensor are at the same positions.
The data is now reported in a larger report than on the old models. It contains all 6 axes plus the 8 buttons. Using JoyWarrior56FR1 via the joystick API is still very similar though, only the range of the value is now 16 bits instead of 14 or 10 bits for the older sensors.
Commands to set the sensor properties have been changed completely and a high performance mode to enable reading data at 6.664 kHz has been added. Software that does directly access the sensor settings on JoyWarrior24F8 or JoyWarrior24F14 has to be modified to work with JoyWarrior56FR1.

4.2 Axis orientation

The sensor data is mapped to match the standard behaviour of joystick axes.

4.3 Data rate

On the joystick interface JoyWarrior56FR1 produces 833 data packets per second. Since the USB is transfering data in 1 ms time slots there will be some jitter in the transfer to the computer. For proper processing data should be buffered and then handled according to the actual 833 Hz rate at which it is generated in the sensor.
The same applies for high performance mode. In high performance mode data is generated at 6,664 kHz. It is then transferred in packets with 10 data sets each. The transfers also happen in 1 ms time slots.

4.4 Operation with Windows

Upon connecting JoyWarrior56FR1 for the first time you may be asked to perform the standard driver install. Usually this installation happens automatically since system drivers are used.
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 the DirectInput API. In addition two generic HID devices should show up in the device manager.
Do not use the joystick calibration function of Windows for JoyWarrior56FR1. If the calibration function is used the data reported by JoyWarrior56FR1 gets modified by Windows.
To get rid of a calibration you have to remove the JoyWarrior56FR1 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.

4.5 Operation with MacOS

On MacOS X access is available via the HIDManager.
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.

4.6 Setting sensor parameters

Acceleration and angular rate can be measured in different ranges. The resolution in each of the ranges is always 16 bits per axis.
There are also some options for additional filtering of the data inside the sensor to reduce noise.
Setting the sensor parameters is done by sending a eight byte command to the joystick function:

0	1	2	3	4	5…7
$00	ARng	AFilt	GRng	GFilt	$00

$00 is the command to set the parameters. They will not be stored persistently until a command to do that is issued (see 4.7).
ARng is the measurement range for the accelerometer. Values $00 to $03 are valid:
$00 - ±2 g
$01 - ±16 g
$02 - ±4 g
$03 - ±8 g

AFilt contains flags to control the input filter of the accelerometer:
7 - Secondary low pass filter (LP2) on/off
6 - High/low pass filter
5 - LP bandwith select
4 - unused write 0
3 - unused write 0
2 - unused write 0
1 - BW-MSB
0 - BW-LSB

The filter chain for the accelerometer starts with a low pass filter (LP1) that is always on. Optionally the output of LP1 can be fed through another low pass filter (LP2) or a high pass filter (HP):

Sec LP (bit 7)	High/low (bit 6)	Mode
0	0	LP1 only
0	1	LP1+HP
1	0	LP1+LP2
1	1	LP1+HP

LP bandwith select must be 0 when the HP filter is enabled. For LP1+LP2 mode it selects low noise mode for 0 and low latency mode for 1. In LP1 only filter mode it selects the cutoff frequency of LP1:

LP Bandwith	Normal mode	High speed mode
0	416.5 Hz	3330 Hz
1	208.25 Hz	1665 Hz

The two BW bits select the cutoff frequency for the LP2 or HP filter:

BW	Mode	Normal mode	High speed mode
00	LP1+LP2	16.66 Hz	133.2 Hz
01	LP1+LP2	8.33 Hz	66.6 Hz
10	LP1+LP2	92.56 Hz	740 Hz
11	LP1+LP2	2.08 Hz	16.65 Hz
00	LP1+HP	208.25 Hz	1665 Hz
01	LP1+HP	8.33 Hz	66.6 Hz
10	LP1+HP	92.56 Hz	740 Hz
11	LP1+HP	2.08 Hz	16.65 Hz

GRng sets the measurement range of the gyroscope. Only certain values are valid, do not write the reserved values to the sensor.
$00 - 245 dps
$01 - 125 dps
$02 - 500 dps
$03 - reserved, do not use
$04 - 1000 dps
$05 - reserved, do not use
$06 - 2000 dps
GFilt allows to activate a high pass filter for the gyroscope data. A low pass filter is always active at 245 Hz for normal mode and 351 Hz for high speed mode.
7 - HP filter on/off
6 - unused write 0
5 - unused write 0
4 - unused write 0
3 - unused write 0
2 - unused write 0
1 - BW-MSB
0 - BW-LSB

HP filter on/off must be 1 for the high pass filter to be activated. The filter cutoff frequency (BW) is independent of normal or high speed mode:
00 - 16 mHz
01 - 65 mHz
10 - 260 mHz
11 - 1.04 Hz

4.7 Storing sensor parameters

The sensor parameters can be stored persistently as the default settings. This allows you to program the sensor once and have it automatically come up in your configuration every time you connect it to the USB.
To store the current setting of parameters send an eight byte report with $01 in the first byte. The rest of the bytes should be zero.

4.8 High Speed Mode

For applications that need a higher sample frequency it is possible to run the sensor in a high speed mode that produces data at 6,664 kHz. Though this data rate is too high to pass through the standard joystick API. Data in high speed mode is delivered via two interfaces that act as generic HID. One handles the acceleration data, the other the gyro data.

High speed mode is enabled and disabled by sending an eight byte report with command code $04 in the first byte and $01 to enable and $00 to disable the mode in the second byte, the remaining bytes must be zero.

The sensor data is returned in reports with 62 bytes each. Each report contains 10 sets of axis data in the sequence X, Y, Z or rX, rY, rZ.

The last two bytes of the report contain the data of the internal temperature sensor which may be used for compensation of temperature induced errors. Accelerometer and gyro use separate endpoints/ interfaces. The accelerometer returns the data on endpoint 3, the gyro on endpoint 4.

Setting the filters or measurement range is not possible while in high speed mode. Set them before enabling high speed mode.

Format of the report data:

Byte
0 - X or rX at t0 LSB
1 - X or rX at t0 MSB
2 - Y or rY at t0 LSB
3 - Y or rY at t0 MSB
4 - Z or rZ at t0 LSB
5 - Z or rZ at t0 MSB
6 - X or rX at t0+1 LSB
7 - X or rX at t0+1 MSB
8 - Y or rY at t0+1 LSB
9 - Y or rY at t0+1 MSB
10 - Z or rZ at t0+1 LSB
11 - Z or rZ at t0+1 MSB
..
..
58 - Z or rZ at t0+9 LSB
59 - Z or rZ at t0+9 MSB
60 - temp LSB
61 - temp MSB

4.9 Temperature Sensor

The temperature sensor reports a 16 bit value in 1/256 °C as a signed value centered at 25 °C.
$E700 = 0 °C
$0000 = 25 °C
$1900 = 50 °C
Temperature data is available only in high speed mode where it is always the last 16 bit value in each data packet.

4.10 Calibration

The sensors are factory calibrated for neutral position and range. There is no need for additional calibration of the sensor itself. Any mechanical offsets have to be compensated on the application side.

5. DC characteristics

	Parameter	Min	Max	Units	Remarks
V_{cc}	Operating voltage	4.35	5.25	V	
I_{cc}	Operating supply current		30	mA	
I_{sb}	Suspend mode current		350	μA	Sensor sleeping
R_{up}	Pull-up resistance (Buttons)	4	8	kΩ	
V_{ith}	Input threshold voltage	45%	65%	Vcc	
V_H	Input hysteresis voltage	6%	12%	Vcc	
	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	
Z_o	USB driver output impedance	28	44	Ω	
V_{crs}	D+/D- crossover voltage	1.3	2.0	V	

5.1 Absolute maximum ratings

Storage Temperature	-55 °C to +100 °C
Ambient Operating Temperature with power applied	-40 °C to +85 °C
Ambient Operating Temperature using USB *	-10 °C to +85 °C
Supply Voltage on VCC relative to VSS	-0.5 V to +6.0 V
DC Input Voltage	-0.5 V to VCC + 0.5 V
Max. Output Current into any Pin	-25/+50 mA
Static Discharge Voltage (USB and button inputs)	>2000 V
Latch-up Current	max. 200 mA
Mechanical Shock **	10,000 g, ≤200 μs

*) Temperatures below this may cause USB connection loss due to frequency drift

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

5.2 Sensor characteristics

	Parameter	Min	Typ	Max	Units
S_{2g}	Acceleration resolution at ±2g		0.061		mg/LSB
S_{4g}	Acceleration resolution at ±4g		0.122		mg/LSB
S_{8g}	Acceleration resolution at ±8g		0.244		mg/LSB
S_{16g}	Acceleration resolution at ±16g		0.488		mg/LSB
$Asens_{drift}$	Temperature Coefficient of Sensitivity		±0.01		%/K
A_{off}	Zero-g Offset	-40		40	mg
A_{drift}	Zero-g Offset temperature drift		±0.1		mg/K
An_{2g}	Noise density at ±2g		90		μg*√Hz (depends on filter)
An_{4g}	Noise density at ±4g		90		μg*√Hz (depends on filter)
An_{8g}	Noise density at ±8g		90		μg*√Hz (depends on filter)
An_{16g}	Noise density at ±16g		130		μg*√Hz (depends on filter)
S_{125}	Angular rate sensitivity at ±125 dps		4.375		mdps/LSB
S_{245}	Angular rate sensitivity at ±245 dps		8.75		mdps/LSB
S_{500}	Angular rate sensitivity at ±500 dps		17.5		mdps/LSB
S_{1000}	Angular rate sensitivity at ±1000 dps		35		mdps/LSB
S_{2000}	Angular rate sensitivity at ±2000 dps		70		mdps/LSB
S%	Angular rate sensitivity tolerance		±1		%
$Gsens_{drift}$	Angular rate sensitivity drift vs. temperature		±0.007		%/K
G_{off}	Angular rate zero level		±3		dps
G_{drift}	Angular rate zero level temperature drift		±0.015		dps/K
Gn	Angular rate noise		3.8		mdps*√Hz (depends on filter)
T_{off}	Temperature sensor offset	-15		15	°C

5.3 EMC

JoyWarrior56FR1 has been EMC tested in a typical use configuration and does comply with CE requirements. Though since JW56FR1-MOD is a component and not a device there is no declaration of conformity for it. CE conformity is declared separately for JW56FR1-WP.

6. Ordering information

Partname	Order Code	Description	Package
JoyWarrior56FR1 Module	JW56FR1-MOD	6D motion sensor complete module	Module
QuakeCatcherKit3	QCKIT3	Kit containing 6D sensor module, cable, enclosure	Kit
JoyWarrior56FR1-WP	JW56FR1-WP	Water proof 6D 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

JW56FR1-MOD modules come in antistatic boxes or antistatic bags packaged single or bulk.
QCKIT3 and JW56FR1-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:
JoyWarrior56FR1 $111A

ProductIDs are independent of the package type.

6.3 Serial numbers

The JoyWarrior56FR1 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

Initial shipping version of JW56FR1 is V2.0.0.0

Legal stuff

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